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SONARMAN 3 & 2

VOL. I

NAVY TRAINING COURSES

NAVPERS 10138-C

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SONARMAN 3 & 2

VOL. I

Prepared By

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

NAVPERS 10138–C

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1957

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ACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS*	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7A
SERVICE	4 mos. service—or completion of recruit training.	6 mos. as E–2 or 8 mos. total service.	6 mos. as E–3 or 14 mos. total service.	12 mos. as E–4.	12 mos. as E–5; total service at least 36 mos.	36 mos. as E–6.
SCHOOL	Recruit Training.		Class A for PR3, PRS3.		Class B for MN1.	Class B for AGCA, MNCA, MUCA.
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.			
PRACTICAL FACTORS	Locally prepared check-offs.		Records of Practical Factors, NavPers 760, must be completed for all PO advancements.			
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.			
EXAMINATIONS	Locally prepared tests.		Service-wide examinations required for all PO advancements.			
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Required for E–3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed.				
AUTHORIZATION	Commanding Officer		U. S. Naval Examining Center			BuPers
	TARS are advanced to fill vacancies and must be approved by district commandants or CNARESTRA.					

*Recommendation of petty officers, officers and approval by commanding officer required for all advancements.

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REQUIREMENTS*		E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7A
	FOR THESE DRILLS PER YEAR						
TOTAL TIME IN GRADE	24 OR 48	9 mos.	9 mos.	15 mos.	18 mos.	24 mos.	36 mos.
	12	9 mos.	15 mcs.	21 mos.	24 mos.	36 mos.	42 mos.
	NON-DRILLING	12 mos.	24 mos.	24 mos.	36 mos.	48 mos.	48 mos.
DRILLS ATTENDED IN GRADE#	48	27	27	45	54	72	108
	24	16	16	27	32	42	64
	12	8	13	18	20	32	38
TOTAL TRAINING DUTY IN GRADE#	24 OR 48	14 days	14 days	14 days	14 days	28 days	42 days
	12	14 days	14 days	14 days	28 days	42 days	42 days
	NON-DRILLING	None	None	14 days	14 days	28 days	28 days
PERFORMANCE TESTS				Specific ratings must complete applicable performance tests before taking examination.			
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)		Record of Practical Factors, NavPers 1316, must be completed for all advancements.					
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Completion of applicable course or courses must be entered in service record.					
EXAMINATION		Standard exams are used where available, otherwise locally prepared exams are used.					
AUTHORIZATION		District commandant or CNARESTRA					BuPers

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#Active duty periods may be substituted for drills and training duty.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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This book is written for men of the U.S. Navy and Naval Reserve who are striking for the rate of Sonarman 3, and for those rated Sonarmen seeking advancement in rating. The book, in conjunction with volume 2, is designed to cover, as nearly as possible, the qualifications of the Sonarman 3 and 2 rates.

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6	3	3,2	3,2
7	3	3	3
8	3	3	3
9	3	3	
10	3	3	3
11	3	3	3
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READING LIST

NAVY TRAINING COURSES

Sonarman 3 & 2, Vol. 2, NavPers 10139

Sonarman 1 & C, Navpers 10140–A

Basic Electricity, NavPers 10086 (chapters 1, 3–5, 7–9, 12–17)

Basic Electronics, NavPers 10087 (chapters 1–9, 12, 13)

OTHER NAVY PUBLICATIONS

NWIP 24–1 (chapters 1–3)

NWIP 24–2 (chapters 1, 3–7; articles 710, 712, 713, 730)

U. S. Navy Safety Precautions, OpNav 34P1 (chapter 18)

Handbook of Test Methods and Practices, NavShips 91828–A (articles 3–12 through 3–16 and 3–17 through 3–19)

USAFI

United States Armed Forces Institute (USAFI) courses for additional reading and study are available through your Information and Education Officer.* A partial list of those courses applicable to your rate follows:

Correspondence Courses

Number	Title
CA 885	*Fundamentals of Radio*
CA 887	*Intermediate Radio*
CB 893	*Television*
CA 781	*Fundamentals of Electricity*
CB 785	*Electrical Measuring Instruments*
CB 290	*Physics I*
CB 291	*Physics II*

*"Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services, and materials if the orders calling them to active duty specify a period of 120 days or more, or if they have been on active duty for a period of 120 days or more, regardless of the time specified in the active duty orders."

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CHAPTER 1

THE SONARMAN

READINESS FOR COMBAT

A Sonarman is an important man in the combat readiness of his ship. An enemy can be engaged only after he is detected, and a ship's ability to detect an underwater enemy depends upon the quality of her Sonarmen.

A Sonarman begins as an operator of sonar equipment, and as his knowledge of his specialty increases, his duties take him into the broader field of antisubmarine warfare. He soon qualifies in operating underwater fire control instruments—the devices that tell when and where his ship's weapons will be launched to destroy the submarine. At the top of his rating, he is a Chief qualified to direct antisubmarine attacks. This means he is capable of taking his ship into combat, directing her course, and launching her weapons. There is no position more responsible than that!

This, briefly, is the rating for which you are striking, or in which you are advancing. In this chapter you will learn that a great many plans have been made for your career as a Sonarman. You will find you aren't the only one interested in your advancement; the Navy wants you to get ahead, too.

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Sonar forms a protective, underwater screen for our task forces and for convoys carrying troops and vital supplies. Fast, highly maneuverable ships are required to maintain this screen. The vessel designed for the job is the destroyer, and it is aboard destroyer types that most Sonarmen spend the seagoing portions of their careers.

When you provide a screen for a task force, you are protecting heavier guns and aircraft until they can be brought within range of the enemy. When you escort a convoy, your only concern is to get supplies through. When you operate with a hunter-killer force, you are out to hunt down and destroy the underwater enemy.

Some Sonarmen serve aboard larger vessels. These include our new frigate class, support and escort aircraft carriers, and tenders. Many Sonarmen put in tours of shore duty in the underwater detection station of a harbor defense unit. Here they find a different but interesting slant on underwater detection. Aviation sonar and submarine sonar are both developing rapidly, and new billets are opening to Sonarmen in these fields of submarine detection.

Eventually you will qualify to train other Sonarmen for the Navy. You will plan and direct shipboard sonar training programs. If you are sharp enough, you may serve as an instructor or staff member of a fleet sonar school or at one of the fleet training centers. As you advance, your contributions to Navy sonar will increase. As a matter of fact, a Sonarman assisted in the preparation of this book.

RATING STRUCTURE

There are many jobs in the Navy and it takes a great deal of planning to get them all done. Jobs re-

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quiring about the same skills, knowledge, and training are grouped under one heading, called a rating. Thus, most of the tasks in detecting and sinking submarines have been grouped in the rating in which you are interested—Sonarman.

Within every rating there are steps for advancement, and with each step there is an increase in pay. These steps, or pay grades, are the rates within the rating. The rating is Sonarman, abbreviated SO, and the rates are Sonarman Third, Sonarman Second, and so forth, abbreviated SO3, SO2, SO1, and SOC.

Navy ratings are gathered in a total of 12 groups, with ratings in a particular group occupationally related. This is to say that all the work of detecting and sinking submarines isn't left to Sonarmen. Radarmen, you will find, can be mighty handy at picking up a periscope or tracking a submarine with the ranges and bearings you supply. Sonarmen are assigned with Radarmen, Quartermasters, and Boatswain's Mates in group I, commonly called the deck group.

QUALS MANUAL

One of the important publications in any enlisted man's career is the *Manual of Qualifications for Advancement in Rating,* NavPers 18068, known throughout the Navy as the *Quals Manual.* Military and professional requirements for advancing as a Sonarman are contained in this publication. It was used as a guide for the contents of this training course, and it will be used as a guide by the examiners who prepare your servicewide competitive examination. Every ship and station has copies of the *Quals Manual,* but for your convenience the section that applies to Sonarmen has been printed as appendix II to this training course. Turn to the back of the book and spend a minute or two studying appendix II. It will help you to understand the discussion of the Sonarman rating which follows.

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GENERAL AND EMERGENCY SERVICE

Men on active duty in the Navy in peacetime hold GENERAL service ratings which may be divided, in time of war, into two or more EMERGENCY service ratings. A general service rating includes all the duties and skills of the particular rating, while emergency service ratings are simply parts of the general service rating. Sonarman (SO) has two emergency service ratings, SOG and SOH. Some general service ratings have no emergency ratings; others have more than two.

A Sonarman on active duty in peacetime must perform competently the duties of a shipboard Sonarman, plus those duties peculiar to harbor defense sonar. The Sonarman G is a shipboard sonar operator with duties that include maintenance and operation of shipboard sonar equipment and operation of certain underwater fire control instruments. The Sonarman H is a specialist in harbor defense sonar and is responsible for operating and maintaining harbor defense sonar gear. He does not operate fire control instruments, but he has added duties in operating magnetic detection equipment and special listening equipments such as sonobuoys and hydrophones. Most Sonarmen drilling with the Reserve are either SOG's or SOH's. All career Sonarmen—those on active duty in peacetime—are SO's. In time of war they, too, become either SOG's or SOH's.

There are two special categories of Sonarmen whose duties are not completely reflected in the qualifications for advancement in rating. These are the general service Sonarmen assigned to submarines or aviation. They are required to take the same servicewide examinations as other general service Sonarmen; but, in qualifying in practical factors, they are required to be proficient in the duties of their billets.

ADVANCEMENT

Before you can advance in rating there are certain military and professional requirements you must fill.

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Military Requirements

Military requirements for advancement are those general qualifications which apply to all enlisted personnel, such as watch standing, first aid, and military conduct. These requirements are published in the *Quals Manual,* near the front, preceding the PROFESSIONAL qualifications for the various ratings. (They are not listed in appendix II.) Before you can advance, you must show that you are proficient in each of the military qualifications specified for the next higher pay grade. You also may be required to demonstrate your proficiency in the military quals for all the lower pay grades.

Professional Requirements

Professional qualifications are those which a Navy enlisted man must have to qualify for a rate (Third, Second, First, or Chief) within a particular rating (Sonarman, Radarman, etc.). The higher the rate, the more the man is required to know. A Chief Sonarman has a thorough grasp of every phase of sonar, and knows in addition a great deal about antisubmarine warfare. There are no sonar jobs he cannot perform.

Appendix II lists the professional qualifications for Sonarman at every rate level. You will be interested in those for Third Class or Second Class, depending upon the rate for which you are studying. Notice in the appendix that the professional qualifications are further divided into PRACTICAL FACTORS (numbered 100 and above) and EXAMINATION SUBJECTS (numbered 200 and above). The practical factors are qualifications that can best be demonstrated by DOING. As a Seaman you were required to demonstrate your knowledge of knots by tying them. It makes more sense to tie a knot than to write about one on paper. In the same manner, your ability to pick out a submarine echo from background noise is something you will demonstrate at the sonar console.

There must be an entry in your service record to prove

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you have qualified in the practical factors before you can take the servicewide examination. There is a special checkoff sheet listing all the practical factors for the rate to which you are advancing. It is kept by your supervisor or your division officer. As you qualify in a practical factor, he enters the date and initials the entry. If you are transferred before you qualify in all factors, the checkoff sheet accompanies your record to the next duty station.

The qualifications listed under examination subjects in appendix II are those in which you can best demonstrate your knowledge by written examination. These are the professional qualifications upon which servicewide examinations are based. An example of an examination subject is a qual that requires you to know the effect of temperature and pressure on the behavior of a sound beam.

As you were told previously, the quals printed in appendix II were taken from the *Quals Manual.* Make a point of checking the manual to see that the quals have not been changed since they were published here. Your ship's office has a copy of the *Manual.*

NAVPERS 10052

After a servicewide examination you are sure to hear someone ask: "Where did they get THOSE questions?" Most examination questions for SO 3 and 2 will be based on material in this training course. But it isn't practical in a course of this type to include all the information a first-rate Sonarman needs. Drop into sonar control and inspect an equipment instruction book, or take a look at the tactical publications concerned with antisubmarine warfare, and you will know why one text can't cover the field. But this isn't as bad as it sounds. The Navy has set definite limits on the material for which you are accountable on examinations. The only sources from which examination items can be taken are listed in a pamphlet

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called *Training Courses and Publications for General Service Ratings,* NavPers 10052. For you, the student, this pamphlet provides the titles of publications and sections of publications WHICH YOU SHOULD STUDY WHEN PREPARING FOR EXAMINATION. Naturally, *Sonarman 3 and 2, Volumes 1* and *2,* are listed there.

Get acquainted with NavPers 10052. After you have read the instructions at the front, there are only two pages of further interest to you. One page contains the sources you should study to meet the military requirements for advancement; the other lists sources for study to qualify professionally as a Sonarman. An asterisk marks the training courses which you MUST complete before you can be eligible for servicewide examination.

To repeat, the *Quals Manual* tells what is expected of you militarily and professionally, and NavPers 10052 tells you where to go to find the information. This pamphlet is readily available on your ship or station. It is revised annually; so be sure to consult the current edition.

HOW YOU ADVANCE

Now, how do you go about getting advanced? First, there are certain basic requirements that must be met, such as length of service in pay grade, total service, sea duty time, and minimum quarterly marks. These requirements vary from time to time, so check with your leading PO or with your division officer to be sure you meet the requirements. In addition, all Sonarmen must meet certain audio acuity standards. A Sonarman must be able to hear well over a wide range of sounds, and must be able to detect slight changes in pitch. No amount of study will get you rated as a Sonarman if you haven't a sharp sense of hearing. If you have not had an audiometer test, have your leading PO arrange one for you immediately. Audiometer tests are given at fleet training centers, fleet sonar schools, and naval air stations, and arrangements for testing are routine.

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Next, you must demonstrate your ability in the practical factors. A statement that you have satisfactorily performed the practical factors for the next higher Sonarman rate must be in your record before you can be recommended for servicewide examinations.

Evidence that you have successfully completed the Sonarman training courses must also be in your record. Your ship may have its own program for testing you on the contents of this course, but more than likely you will be required to complete a correspondence course for Sonarman 3 or 2. In any case, the questions on the assignments will be based on the contents of this book and *Sonarman 3 and 2, Volume 2*. Possibly you are studying this text without having enrolled in the required correspondence course. Don't wait to be told to enroll. Give yourself as much as a year in advance of the fleetwide examinations to prepare properly. But, more about correspondence courses later.

Before you can take the servicewide competitive examination, you must be recommended by your commanding officer. His recommendation will take into account such matters as your leadership ability and your personal integrity. If you pass the examination with a high enough score, your commanding officer will be given authority to advance you in rating. Remember, though, you can pass the examination and still not be advanced. Here is the reason: It is sometimes necessary to establish quotas, and only those men making the highest scores are advanced. One of the aims of this training course is to see that you receive one of those "highest" scores. The two volumes in this course will become the basis of your knowledge of sonar; the more you learn from them, the better equipped you will be for the Sonarman rating.

ABOUT THIS BOOK

Probably the most sensible approach to your studies is first to understand the general makeup of your text. This book is a self-study course written to help you be-

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come a Sonarman with the least possible outside assistance. There are features to the book, such as the preface, study guide, and appendices, intended to make your studies easier and more effective.

There is always the temptation to skip the front matter and get on with this thing called sonar. But this is apt to be a costly shortcut. If you have hurried through the front matter to get to chapter 1, there is no better time than now to scan that material. The preface, for instance, will give you the scope of this training course and explain why it was written in two volumes. By all means, read it. The reading list is important because it is the basis of your sonar reference library; and the study guide on page iv is likely to save the SOH's and SOG's a lot of effort.

Each chapter of this book closes with a quiz that should be a quick, reliable check of what you have learned from material you have just covered. The answers are in appendix I.

Many students lose valuable time because they make little use of the index. You can think of the index as an alphabetical list of the high points or key words in this book. Almost every aspect of sonar you can think of will be listed under a key word in the index along with the page or pages where the subject is discussed.

Sometimes the information you need is found more easily in the table of contents. This will be true when the subject is broad or general, as, for example, information about sonar range recorders. If you need specific information about a particular sonar range recorder, then the place to go is the index. Chances are the information will be listed in more than one place under different key words. No matter which of the key words you select, the index will lead you to the right page.

HOW TO STUDY

Good study practices are those that get the best results for you. Some suggestions for getting the most out

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of the course are included here, but, in the end, your study practices are what you make them.

As in almost any task you undertake, a little planning will increase effectiveness. Begin by setting aside a part of each day for study. It doesn't have to be a long period of time; you will be surprised at the results that 15 minutes of concentrated study daily will produce. Once you are underway, work at it steadily. You are much better off studying a little bit often than studying a lot once in a while. As a matter of fact, you shouldn't attempt to absorb too much information at a time.

Then there is the matter of retaining what you have learned. There are passages in the text which you will read several times because you can't retain all the information with a single reading. Make a point of summarizing what you have read, restating the information in your own words. It's also a good idea to take notes, especially when the going is difficult. Also, make a point of discussing what you have learned with other strikers, or with Sonarman petty officers. It will help you fix ideas firmly in mind.

Use every opportunity to check what you have learned against equipment operation on your ship or station. If your ship lacks a particular piece of equipment, arrange to observe its operation on another ship. As an active duty Sonarman or striker you will never be far from the major sonar equipments used by the Navy. If you drill with the Reserve, your opportunities to work with late-model equipments will be limited. In this case, make the best use of your annual active duty for training. Try to get duty aboard destroyer types, and don't pass up training at the sonar schools.

Test your progress by answering the questions at the end of each chapter. If there are any you can't answer correctly and with confidence, go over the textual matter again. If you are still puzzled by the material, ask the leading Sonarman to explain it for you. He will be glad

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to square you away, for one of his duties is to help the Navy train good Sonarmen.

Correspondence Courses

Follow the same plan for a correspondence course. You won't get very much from the course if you simply search through the text trying to answer each question as you come to it. Read and study the text, then answer the questions. After you have answered as many as you can, check your answers against the text, and proceed to review material for answers to the remaining questions.

Other Opportunities

A great deal has been said about self-study and moving ahead on your own. Actually, in most instances you will have the additional benefits of a shipboard or Naval Reserve training program, including contact instruction, lectures, and demonstrations. Opportunities to attend courses at the fleet sonar schools are available to all Sonarmen.

SONARMAN AND COMBAT READINESS

There are rewards in being a Sonarman greater than the satisfaction of advancement and increased pay, although these are important. When your ship in peacetime gets an outstanding mark in her operational readiness inspection, you have had a big hand in it. Among other things, an outstanding mark means the ship is in all respects ready for antisubmarine warfare and she has demonstrated this by a series of successful attacks on a submarine in full evasion. It means you detected the target and never let it slip from your sound beam, though she tried every trick in the submariner's book. You have the satisfaction of a job done well, and something more. It is a thing called prestige and it means you rate with your

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shipmates, and your ship rates with the squadron and task force or group in which she operates.

In time of war it is the Sonarman who most often sounds the alert for underwater combat. The GQ alarm brings men to their battle stations, but it is the Sonarman's warning that sounds the GQ alarm. Often, he and the sonar team are launching the first attack against a submarine before the ship's crew has manned all battle stations.

Your ability as a Sonarman won't pass unnoticed. There are men ahead of you who moved up with a letter of commendation in their records attesting to their proficiency as Sonarmen. You begin as a sonar operator, and, one day, you are the leading PO, in charge of the sonar gang. You advance in rating to Chief and you continue to apply yourself. You can be a Warrant Electronics Technician, and you can be commissioned a limited duty officer (LDO), specializing in electronics. You will advance by studying, by training, and by sticking with it. It takes a willingness to learn and a willingness to work.

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QUIZ

1. Name the Sonarman emergency service ratings.
2. What type of rating is held by Sonarmen assigned to submarines or aviation?
3. How are professional qualifications for advancement in rating divided?
4. Why is NavPers 10052 important both to the student and the examiner?
5. Name the ratings in the deck group.
6. How does a rate differ from a rating?
7. What is the difference between sonar and antisubmarine warfare?
8. To which warrant rank can a Chief Sonarman be promoted?

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CHAPTER 2

SUBMARINES AND SONAR

During the Revolutionary War, an American inventor named David Bushnell designed a strange-looking boat that could submerge. His idea was to get under enemy ships, drill a hole in their wooden hulls, and attach a mine. He launched an attack against the British frigate *Eagle*. Although the attack was unsuccessful, the idea of submarines was there, and it grew until the submarine became a potent weapon for attacking ships.

The first submarine to sink a vessel in wartime was the Confederate *Huntley*. Her victim was the Union frigate *Housatonic*.

In World War II, submarines sent millions of tons of shipping to the bottom. In what since has come to be known as the Battle of the Atlantic, the U. S. Navy and her allies teamed together to hunt down underseas raiders, thus gaining one of the important victories of the war. The submarine's greatest advantage then, as now, was that it could operate beneath the ocean surface where detection was nearly impossible. Sinking a submarine was comparatively easy, once it was found; but finding it before it could attack was another matter. There were those who said that submarines could be detected by using high-frequency sound waves. The method was to project a beam of sound through the water, and then listen for a returning echo. Range and bearing of the echo would locate the underwater object.

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The device for transmitting the signal and receiving the returned echo was called SOund Navigation And Ranging equipment, and is with us today under the short title, SONAR.

THE SUBMARINE

Men who hunt should know their quarry well, and Sonarmen should know about submarines. How fast can a submarine dive or turn? How does the submariner use depth? Does cavitation help or hinder the submarine? Because this is an unclassified text, many of the answers are general. But in your studies you will learn all you need to know about enemy submarine characteristics and tactics to make it easier for you to detect them and to hold contact after detection.

A submarine is a cigar-shaped boat ranging in length from about 50 feet to more than 300 feet. The hull is surmounted by a low conning tower, which is the bridge when the boat is surfaced, and provides space for a conning room when the craft is submerged. The conning tower is mounted on either a single or double pressure hull, which, in most cases, is surrounded by an outer hull containing ballast or fuel tanks. (A double pressure hull in cross section resembles the figure 8, and provides another deck level within the boat.) The pressure hull is built of extremely tough steel to enable the boat to withstand pressure at great depths and the impact of antisubmarine weapons. Bulkheads, ribs, and the sides of tanks add to rigidity.

In figure 2–1 you see a modern version of the long-range fleet submarine that served the U. S. so notably in World War II. As you can see, the bridge deck has space for periscope shears, periscopes, and radio and radar antennas. The conning tower, which is the fire control center and primary navigating station, has an access hatch to a control room below. On the main deck are two rescue and escape hatches, messenger buoys for re-

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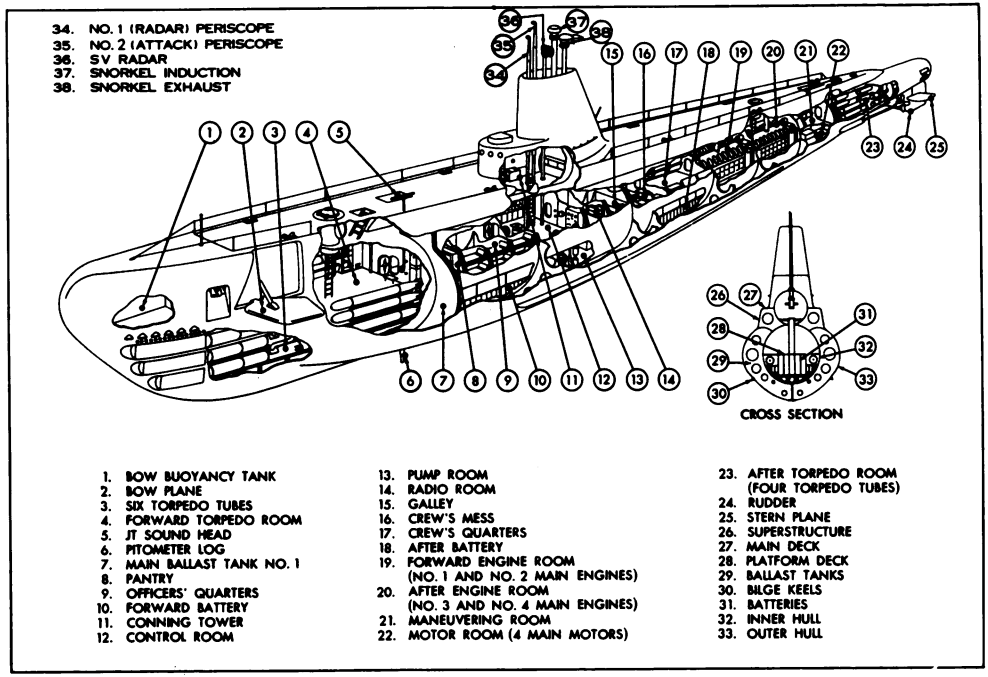

Figure 2–1.—Modified fleet-type, or Guppy, submarine.

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lease when the submarine is disabled, two torpedo loading hatches, capstans fore and aft, a hydrophone, galley access hatch, and the after engineroom hatch. There are deck fittings as required for shiphandling. A study of figure 2–1 provides details of the submarine's compartmentation.

Operating characteristics of submarines vary according to the boat's size, which is usually dictated by its mission. A troop carrier or tanker submarine will be larger and slower than one designed for war patrols, and considerably larger than submarines specifically intended to penetrate enemy harbors. Probably the smallest submarines in the world belong to the ex-German *Seahound* class (now in Russian possession), which are 49 feet long and displace only 15 tons. Somewhat heavier, but still in the midget submarine class, are the U. S. Navy's *X–1* and the British *Shrimp* class. The *X–1* is less than 50 feet long and displaces 25 tons; boats of the *Shrimp* class are slightly longer and displace 30 to 35 tons.

At the other extreme are the long-range patrol and fleet types, and the U. S. Navy's nuclear-powered submarines. These boats exceed 300 feet over-all and, submerged, displace approximately 3000 tons. The Russian improved *K* class is typical of this group: 320 feet over-all, 2900 tons submerged, and 20,000-mile range. The improved *K* class is equipped with snorkel (or snort) for bringing air to the crew and engines when operating submerged on diesels. Rated speed is 20 knots surfaced and 16–17 knots submerged.

A type of submarine widely used by the Germans in World War II, and now a part of the Russian fleet, is the so-called 500-ton U-boat. This boat can dive at a rate of 1½ feet per second. If it turns while diving, it will not advance as far nor dive as deeply as in a straight dive. It can turn 90° in a little over a minute, turning with full rudder and an effective speed of 5 knots.

In diving, the submarine closes all hatches and takes enough water into its tanks to reduce its buoyancy as

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nearly as possible to zero. The actual dive is controlled by manipulation of the hydroplanes, one pair forward and one pair aft. If necessary, a dive can be made in as few as 35 seconds. When a submarine wants to surface, the water in the ballast tanks is expelled by compressed air or pumps.

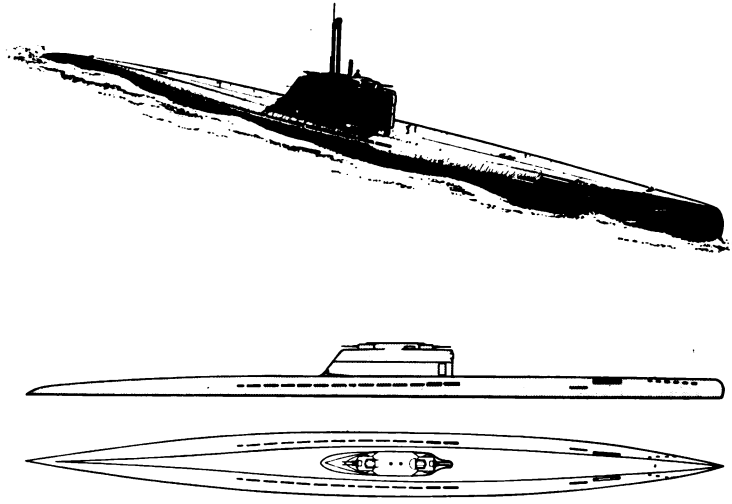

Figure 2–2.—Improved Russian 19 *K* class submarine.

On the surface, the submarine's twin screws are turned by diesel engines (also by steam in the case of nuclear-powered craft) which may drive the submarine at 22 knots or better. Upon submerging and using snort, virtually the same performance can be had, but depth of submergence is limited to the length of the snorkel which is between 30 and 40 feet. Submerged to greater depths, the submarine relies on battery-powered motors, because combustion engines require far more air than is available. Here endurance is strictly limited to the condition of the batteries. In theory, if batteries are well charged, a speed of 1 knot can be maintained for about 50 or 60 hours. At full speed, however, the batteries are exhausted after about 1 hour.

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A submarine may save its batteries by lying on the bottom if the water isn't too deep, but its ability to remain hidden there is restricted by the air supply. In an average fleet-type boat, the air will last comfortably for about 24 to 30 hours. Oxygen is usually carried in flasks in quantities sufficient to sustain life in emergencies for as long as 4 or 5 days. But sooner or later the submarine must come up for air, and for a chance to charge its batteries with the aid of diesels. In enemy waters this is usually possible only at night. One way of forcing a conventional submarine to the surface is to outwait its staying power—the submarine eventually must surface or use its snorkel.

Submarine Missions

Submarines perform many missions. Here we can consider some of the uses of our own submarines, keeping in mind that the submarine is just as widely employed by all the major navies of the world. A good design in one navy is very likely to be adopted or improved upon by another navy. The snorkel is an example of a trend in submarine design rapidly adopted by other countries. Invented by the Dutch and perfected operationally by the Germans, it shortly appeared on British, U. S., and Russian submarines.

Operational needs of the submarine fleet have brought into being the types listed below. Functional and short titles are U. S. Navy designations, and indicate in general the mission of the boat.

Attack submarines	(SS)	Nuclear powered	(SSN)
Experimental	(SSX)	Oilers	(AGSS)
Cargo	(ASSA)	Radar picket	(SSR)
Guided missile	(SSG)	Target	(SST)
Hunter killer	(SSK)	Troop carriers	(ASSP)

This by no means exhausts all the different types of submarines, nor does the list indicate all the various as-

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signments each type is capable of completing. But with all this variation in design and mission, the basic underwater enemy remains the long-range attack submarine, always on the offensive, with but one mission—sending surface ships to the bottom by torpedo fire. This is the submarine which has cut out your job for you as Sonarman.

Submarine Armament

The submarine's principal weapon is the torpedo, which is itself a miniature submarine, 21 inches in diameter and about 20 feet long. The fleet-type submarine is provided with 10 torpedo tubes, from which torpedoes are fired by compressed air.

Torpedo warheads are loaded with HBX, with some types carrying nearly 1000 pounds of explosive. The torpedo has automatic control devices that hold it on a preset course at a preset depth. It is designed to sink at the end of an unsuccessful run.

Torpedoes are propelled by gas turbines or electric motors. Turbine types have speeds of from 30 to 45 knots; their maximum effective range may be as much as 7½ miles, although a submarine will rarely chance a shot at that distance. Electric torpedoes have less range and speed, but they have the advantage, from the submarine's point of view, of leaving no wake.

An acoustic homing torpedo can steer itself toward its target. It may be either "active" or "passive." The active acoustic torpedo sends out pulses of sound, and homes on the echoes that return from the target. Passive types home on the noises of the target ship's propellers. Surface ships sometimes use noisemakers to defend themselves against passive acoustic torpedoes. This gear is towed astern and makes more noise than the ship's propellers. Thus it tends to decoy the torpedo away from the ship.

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Most submarines carry echo-ranging and listening equipment, plus equipment designed for listening only. In principle, submarine echo-ranging gear is the same as that used by surface craft, but tactical use of the equipment varies considerably. Submarine LISTENING equipment is designed to give exceptionally sharp bearings, yet is sensitive enough to detect sounds at 10- to 12-mile ranges. Submarine listening ranges are long because the sound has traveled to the submarine one way, and was not weakened by reflection.

Any ship or submarine moving through water makes certain sounds. Listening for these sounds is the job of the submarine Sonarman. The most important sound is that of propellers as they churn through the water. Next in importance are the noises from various pieces of machinery within the vessel. These sounds go through the hull and out into the water. Even with the vessel dead in the water, propellers and machinery secured, some sound may come from waves slapping against a surface ship's hull. When an antisubmarine vessel is in the vicinity, the pinging of its echo-ranging gear is carefully monitored and reported to the submarine conning officer.

A disadvantage of listening sonar is that it offers no means of determining accurately the range to the target. A submarine Sonarman must rely on experience to tell him, for example, whether he hears a large vessel proceeding slowly, miles away, or a small one proceeding at about the same speed, but near at hand. When a submarine conning officer needs the range of a surface ship, he may order his sonar operator to take a SINGLE PING. In this procedure, the echo-ranging gear is adjusted for a single sonar transmission. Because the transmission is skillfully timed to fit into the echo-ranging pattern of the surface ship, it takes a sharp surface Sonarman to detect that single ping. Against an A/S vessel the ping will come at short range, and it generally will mean the

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submarine is desperate and hopes to survive by beating the A/S vessel to the attack.

When in an area with surface units, the submarine Sonarman spends much of his time listening to prop beats and counting the turns of surface ship screws. From characteristics of the prop beat, the submariner frequently can identify the type of ship, and from the turn count he will know her speed. Equally important, he listens for CHANGES in the turn count indicating his target has changed speed and that the torpedo problem requires a new solution.

Other Equipments

A submariner in a completely submerged boat does not operate "blind." As a matter of fact, he is likely to have far more information concerning your ship's movements and whereabouts than you will have about him. He has a depth gage to tell him how near he is to the surface and a fathometer to give him the distance from his keel to the ocean bottom. He carries a hull-mounted thermometer, called a bathythermograph, which readily supplies the temperature reading at any depth the submariner chooses. In a later chapter you will learn that temperature is an important factor in the behavior of sound under water. It is a simple matter for the submariner to select the depth at which he can operate with the least chance of detection. On the happier side, the most favorable depth may not be one from which he can launch a successful attack.

A submariner can use sonar to communicate with other submarines when surfaced or submerged. However, he isn't likely to use either sonar communications or fathometer in combat situations because of the sound output.

When operating near the surface, the submariner may use one of two periscopes, a very thin one for setting up an attack, or a larger one with which he searches.

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These project from 20 to 30 feet above the top of the hull. The attack periscope is raised a few additional feet for quick sights when the submarine is at proper depth and otherwise completely submerged. Without surfacing completely, the submariner can conduct searches with radar, radio direction finder, and electronic countermeasures (ECM) equipment.

Noise Output

To keep its operation as silent as possible, every submarine is checked periodically for noise output. Before the submarine is ready for a war patrol, the noise level must be at or beneath a minimum acceptable level. While on patrol, the submariner continues to monitor the noise output to determine whether the boat is getting noisier. If this is the case, the noise level monitor indicates the source of increased noise.

Submarines also carry special equipment called a cavitation indicator. Cavitation is noise generated by propeller blades as they cut through the water; the faster the blades move, the more cavitation. Generally, cavitation is not present at low speeds. With acceleration, it comes in suddenly and rises sharply; how loud it will be depends upon the particular submarine, its keel depth, and the rate of acceleration. When you think of the increasing submerged speeds of modern submarines, bear in mind that high speed always means telltale cavitation. On the other hand, keep in mind that the submariner KNOWS when his boat is cavitating, and will permit the condition only as a part of a calculated risk.

Submarine Operations

Submarines generally operate under orders radioed from their own naval headquarters. For instance, a submarine sighting a convoy will radio its findings to headquarters, which may order, in turn, a concerted attack by other submarines in the vicinity. It may be necessary

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for the submarine making original contact to trail the convoy for several days before a pack of submarines can gather. In the process, the trailing submarine may be forced to lose the convoy, for if direct contact is maintained continually, the submarine itself risks detection.

There is no fixed pattern for either individual or group attacks. A submarine must maneuver into good position for attack, and it must aim and fire its torpedoes so as to hit the target. The torpedo must be aimed ahead of the target to allow for the distance traveled by the target while the "fish" are in the water. Because of this, and because the range at which torpedoes can be fired accurately is limited, it is to the submarine's advantage to get somewhat ahead of the target and close in as much as possible before firing.

If the target is escorted by antisubmarine vessels, the submarine will risk detection in closing the range. With a slow convoy, however, the number of escorts is rarely adequate to screen completely all avenues of approach. The first sign of a submarine's presence may be the explosion of a torpedo, for it is possible for a submarine to press home an underwater attack before being detected. Whether the submarine escapes after the attack depends on the effectiveness of the antisubmarine force.

The depths to which submarines dive on being attacked will vary. Generally, depths of 150 to 250 feet are not exceeded unless the first A/S attack comes dangerously close. When pressed, dives of from 300 to 1000 feet can be expected.

Submarine Tactics

Depth has always been an important source of protection for the submarine. But, with new developments in submarine propulsion, submerged speed is rapidly increasing in importance. You should know something of how a submariner will use high underwater speeds. First, he will use it to get into favorable position for attack,

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and again to get into position for reattack. In a tight spot, he will use speed to attempt escape. He is not likely to use speed in the approach just before an attack, because speed means cavitation and cavitation means noise. He wants surprise on his side of the fight; so he isn't likely to make it easy for you to detect him.

In skirting a convoy or otherwise moving into attack position, he will use high speeds only at distances beyond sonar detection range. Even when escaping he may use only a short burst of speed, thus removing the noise spoke from your sonarscope AS QUICKLY AS POSSIBLE. A short speed burst may be followed by a deep dive with sharp turns. He may use his speed to create a knuckle, forming a sound barrier between him and the A/S ship. The idea is to confuse the sonar operator and get him to interrupt or delay his search.

Submarines try NOT to be detected. They listen for surface vessels when submerged, and keep a sharp lookout for air and surface craft when surfaced. If possible, they will stay hidden during the day and surface only at night. If they are caught on the surface, they will dive as quickly as possible.

A submarine will evade an attacking ship by diving, changing speed, or turning. It may lie still on the bottom in shallow water, or take advantage of poor sonar conditions that exist in riptides and near the mouths of rivers. A submarine will float into a harbor, running silent or with engines dead. It may attempt to penetrate by cruising under an incoming vessel for which harbor nets and booms have been opened.

Submarine Trends

Submarine trends today are toward greater submerged speeds, deeper operating depths, and more staying power. The aim is to design a true submersible—one that can operate indefinitely without surfacing. The day when submarines will slug it out on the surface is nearly gone.

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Nights when a submarine can be detected surfaced, charging batteries, are also nearly gone. A modern submarine will use snort to charge batteries without surfacing. With nuclear power, batteries can be charged at any time and any depth, and eventually there may be no batteries to require charging. In the matter of staying power, the *Nautilus* has steamed a distance equivalent to circling the globe without refueling.

SURFACE SHIP SONAR

Sonar is a means of detection. You can't sink a submarine with sonar any more than you can knock down an airplane with radar. Sonar is the primary means of detecting a completely submerged submarine, and the ONLY means a surface vessel has of detecting an underwater target. The only other way that a completely submerged target can be detected is by magnetic loop. In this method, the submarine upsets the magnetic balance in the area of the loop and thus indicates its presence. Loops are planted at the bottoms of harbors and they may be airborne by planes and lighter-than-air craft; they are never a part of surface ship antisubmarine warfare.

Antisubmarine warfare is a broad term that includes sonar detection, solution of the underwater fire control problem, and underwater weapons and their control. The abbreviation for antisubmarine is A/S, and you will find it used in this text to indicate A/S operations, A/S ships, A/S officers, and so forth.

As long as you remain a Sonarman, your primary concern will be sonar detection. As you learned in chapter 1, when you advance in rating you learn to operate underwater fire control instruments, until, as a Chief Sonarman, you are capable of directing an attack against a submarine. Weapons, the third part of antisubmarine warfare, are mainly the concern of ordnance ratings. Gunner's Mates and Torpedoman's Mates are responsible

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for stowing, loading, and, in general, maintaining the weapons.

Sonar can be used for detection in two ways, by echo ranging and by listening. For a number of reasons, echo ranging is the most effective for shipboard use. Listening techniques have wide application in submarines and harbor defense, but only limited application aboard ship, as you will learn later.

The sonar equipment you operate is located in a space called sonar control. This space may also contain one or two fire control instruments, sound-powered phones, and interior communication (MC) circuits. In some vessels all A/S detection and fire control equipment will be centered here and attack runs will be made from this location. On larger A/S vessels there is an underwater battery plot room (UB plot) which contains the major fire control instruments, including remote firing panels. UB plot accepts information from sonar control, solves the underwater fire control problem, and launches the weapons.

The chief instrument in sonar control is the sonar console, also known as the sonar stack. Sitting at the console, you will control your ship's underwater search by projecting high-frequency sound waves into the water and listening for a returning echo. With each transmission, or ping, sound goes into the water 360° about your ship, and a spiral of light starts from the center of the cathode-ray scope on the console and travels to the outer edge of the scope. All underwater objects that reflect energy from your sound beam will appear as pips on the scope. The scope will also indicate the bearing (direction) and range (distance) of the object. If your equipment is set up for a 3000-yard scale and you detect a target on the starboard beam at 1500 yards, the pip will appear to the right of the center of the scope, halfway between the center and the outer edge. If the target was dead ahead, the pip would appear along an imaginary line from the center to the top of the scope. Although you

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can read range and bearing directly from the scope, in practice you will get this information from range and bearing dials on the console. Figure 2-3 shows the sonar situation around a ship and how the information is pictured on the scope of a sonar console.

Thus far you have seen what amounts to a map of the underwater objects about your ship; but, as far as this discussion has gone, you have HEARD nothing. Each time your equipment transmits, a spoke of light flashes on the scope. This spoke of light, or cursor, represents what

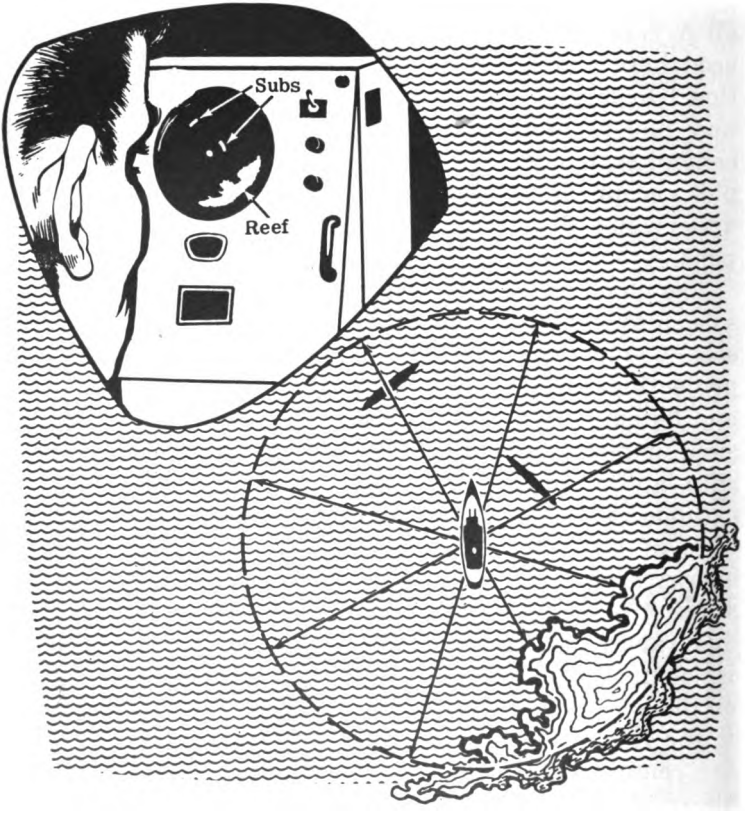

Figure 2–3.—Presentation on a sonarscope.

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is known as the audio channel of your equipment. Any sound returning to the ship along the bearing on which the cursor is trained will be heard at the console. It amounts to this: You see echoes on the scope from every direction, but you hear them along only one bearing, which you as the operator select. Your eyes can separate the pips in bearing, but your ears, listening to sounds from all directions piped into one speaker, could never separate them in bearing. The cursor is controlled by a handwheel, and can be trained manually or slewed automatically. In slewing, an electric motor continuously trains the cursor clockwise or counterclockwise, depending upon your selection. In one type of sonar set, the cursor is slewed at 8 rpm's.

Besides supplying the bearing of an object, the cursor can also be adjusted to provide the range. In normal search, with no targets about, the equipment is set to operate so that the cursor flashes the entire distance from the scope's center to its outer edge. To get the range of a target, the cursor is held on the target's bearing and, by manipulating a knob, is shortened until the tip of the cursor touches the pip. At this point the range dial will indicate the range to the target.

A/S TERMS

There are many important terms peculiar to antisubmarine warfare, both definitions and abbreviations, which you must learn. In this first general discussion of the sonar console, you should know that there are three terms pertaining to the console which are used practically interchangeably and mean the same thing. You will learn your equipment transmits, and that it keys, and it pings. The first is not used so often in sonar, but you frequently will hear the terms "keying" and "pinging." The equipment keys when it sends sound into the water, but the sound of the outgoing signal heard at the console is called a ping. Furthermore, you can adjust the KEY-

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ING INTERVAL at the console; that is, you can make the equipment recycle quickly or at long intervals. The exact use of this control will be discussed in a later chapter.

Ultrasonics

You have many hours in many watches ahead of you at the console, and you are going to hear a lot of pings. To make the listening easier, the sound that comes from the speaker is tuned to about 800 cycles. You know from your audiometer tests that the human ear is capable of detecting sounds from about 15 cycles per second to something in the vicinity of 18,000 cycles (18 kc) per second. It has been determined that 800 cycles makes the most pleasant listening for extended periods.

While on the subject of sound frequencies, here is a new term for you: ULTRASONIC. The Navy refers to sounds at frequencies above range of detection by the human ear as ultrasonics. Two sonar sets in common use, AN/SQS–10 and AN/SQS–11, key near 20 kc and 25 kc, respectively, both ultrasonic. The sound in your speaker has been stepped down to approximately 800 cycles.

TRANSDUCER

The sonar console is not an isolated piece of equipment. It must connect to a power source and to other components that allow it to perform alternately as a transmitter and as a receiver. And, like radar, it must have an antenna. The sonar antenna is called a TRANSDUCER and is located in a metal dome near the keel of the ship. In destroyers it is located approximately one-third of the ship's length abaft the stem. A transducer is a very special kind of antenna: It accepts electrical energy from the sonar transmitter and converts it to acoustical or sound energy for transmission into the water. Then it becomes a receiving antenna, accepting acoustical energy (the echo) which it changes to a small electrical pulse. This is amplified and presented at the

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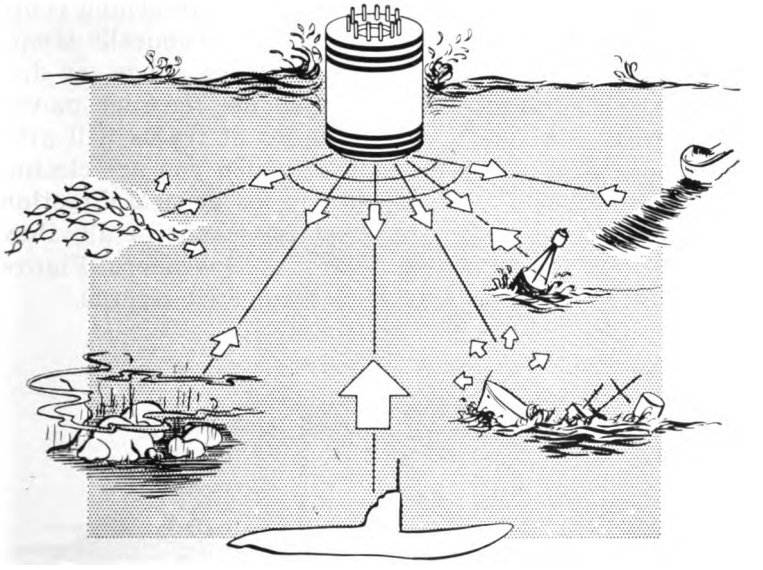

Figure 2–4.—Scanning or azimuth search sonar transducer at work.

console as a visual display and as a sound you hear through the loudspeaker. You take it from there.

Exactly how the transducer does its job will be the subject of detailed discussion in the chapter on sonar equipment. For a first glimpse of a transducer, see figure 2–4. This is a scanning or azimuth search type, so named because it transmits sound through an azimuth of 360° and then samples or scans the returns from every bearing. Older sonar sets, called searchlight equipment, transmitted on only one bearing at a time and gave no visual presentation.

RANGE RECORDER

The first piece of underwater fire control gear you will learn to operate is the tactical range recorder, referred to as the TRR. Your training on the TRR will come almost simultaneously with training on the sonar console.

The TRR is the oldest and one of the most reliable underwater fire control instruments in the Navy. It

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operates as a time-range plot. With each returning echo, a stylus burns a trace on the recorder's chemically treated paper. This provides a record of the range, or distance, to the target. The paper in the recorder moves downward at a steady rate. A series of traces will give you the RANGE RATE—the rate at which you are closing the target. Traces also can tell you the general direction the target is heading and, most important of all, they will indicate the launching time of A/S weapons. Figure 2–5 illustrates the type of traces the TRR records.

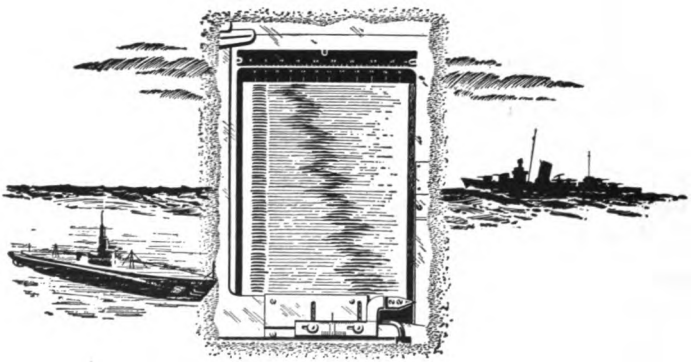

Figure 2–5.—TRR traces.

Figure 2–6 is a cutaway of an A/S vessel showing sonar control and sonar equipment down to the transducer. If you knew your search procedure and had someone to operate the recorder, you would be ready to detect and track submarines, and to determine launching time for A/S ordnance.

A/S ORDNANCE

A/S ordnance can be divided into two broad categories: those weapons which are thrown, including rockets and a 7.2-inch projectile called a hedgehog; and those which are not thrown, including torpedoes, depth charges, and depth bombs. Throwing weapons, in general, are

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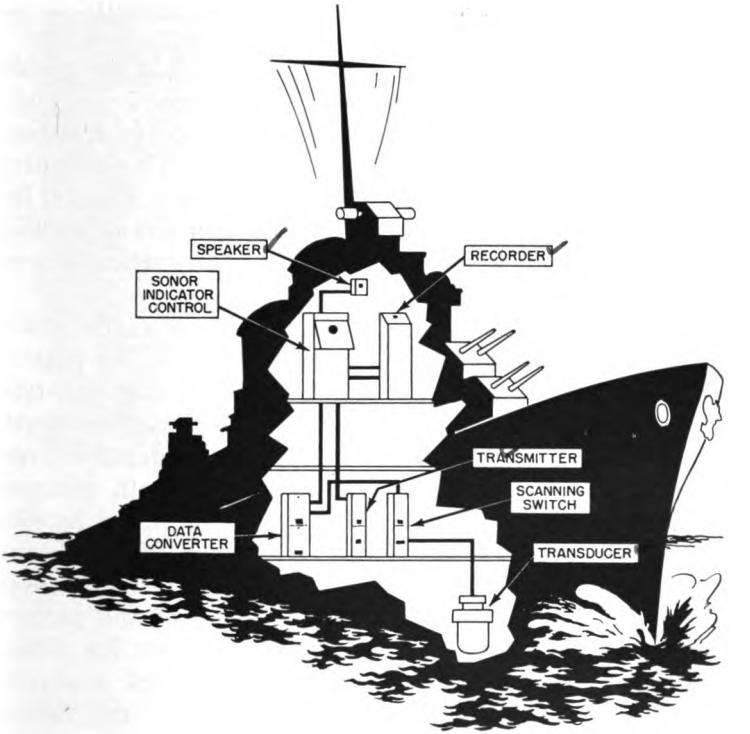

Figure 2–6.—Sonar spaces aboard an A/S vessel.

those which are fired through the air to launch an attack ahead of the ship. The depth charge can be fired by K-guns a distance of 125 yards to either side of a ship, but it nevertheless is not classified as a throwing weapon.

Depth Charges

Depth charges are large explosives in a case shaped like a teardrop or a blunt bomb. One type, the Mk 9, contains 195 pounds of HBX surrounding a central tube. At one end of this tube is the booster charge; at the other end, the pistol or firing mechanism. On the outer end of the pistol is a graduated dial or pointer by which

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the charge can be set to explode by water pressure at any depth within its range.

As the charge sinks, water is admitted at both ends. When the proper pressure (depth) is reached, the pistol is released to ignite the booster, which already has been moved into position by water pressure. The resulting detonation of the booster sets off the entire charge. Because water pressure is used both to arm and to explode the charge, the charge is said to be hydrostatically armed and hydrostatically fired.

Another depth charge, the Mk 14, uses a Mk 9 case and in many respects is similar to the Mk 9. An important difference is that the Mk 14 has an influence-type fuze, which fires when the charge passes near the target. Figure 2–7 is an illustration of the Mk 14 depth charge.

There are two methods of launching depth charges. They may be rolled from the stern, or launched by side throwers (K-guns) which hurl them out on the beam. Ordinarily the charges are dropped in patterns to cover a large area. To add to the effectiveness of the pattern in depth, hydrostatically fired charges are set for different depths within the pattern. While the attack is always calculated with reference to one charge—the center charge in the pattern—the possibility of error makes it necessary to launch many charges in a pattern. A normal pattern may consist of five to occasionally as many as 30 charges.

A depth charge explosion generates waves of high pressure, tending to destroy nearby underwater objects. And an underwater explosion can do greater damage than an equal amount of explosives set off in the air. Nevertheless, modern submarines are so strong that a charge must explode within a few yards of the pressure hull to have lethal effect. Destruction cannot be certain unless the pressure hull of the submarine is penetrated and one or more compartments flooded. Explosions beyond lethal range will possibly cause leaks in the hull, oil or air leaks, jamming of hydroplanes, or other forms of dam-

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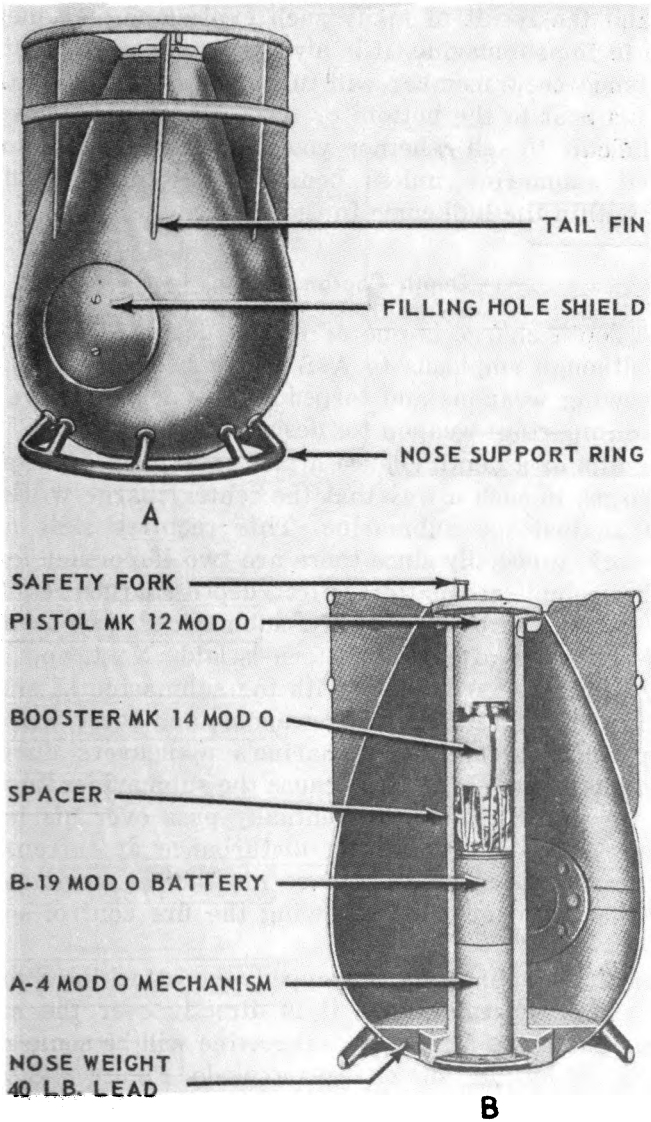

Figure 2–7.—Depth Charge Mk 14 Mod 0. A. Exterior. B. Cross section.

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age, and the result of many such explosions may mean death to the submarine. It is always possible, too, that a frightened crew member will turn the wrong valve and send his boat to the bottom or to the surface. However, it's difficult to tell whether you have destroyed a submerged submarine unless bodies or essential fittings from within the hull come to the surface.

Depth Charge Attack

The depth charge is one of the earliest A/S weapons and, although emphasis in A/S attack has since shifted to throwing weapons and torpedoes, the depth charge is still an important weapon for destroying submarines.

The aim of a depth charge attack is to drop a pattern of charges in such a way that the center charge will explode against the submarine. This requires skill and teamwork, especially since there are two important factors that complicate matters. First, depth charges require time to sink, thereby giving the submariner time to maneuver his boat after the pattern is laid. Next, you are going to lose sonar contact with the submarine at short range, just before launching weapons, and there will be no information on the submarine's maneuvers during this period of lost contact. Because the submariner knows that the sound beam will eventually pass over his boat and the echo will be lost in disturbance at extremely short range, he is likely to save his radical movements until that moment, thus throwing the fire control solution in error.

Unless the submarine is stopped, the attacking vessel cannot drop charges when it is directly over the submarine and score a hit. The submarine will be some distance away by the time charges explode. Figure 2–8 will give you an idea of this action.

If the submarine is moving straight along the ship's path, it is a fairly simple matter to allow for sinking time of the depth charges. If the ship is approaching the

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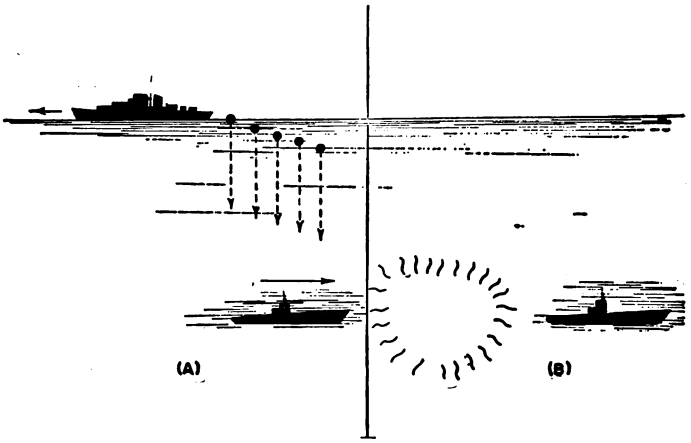

Figure 2–8.—Charges dropped too late.

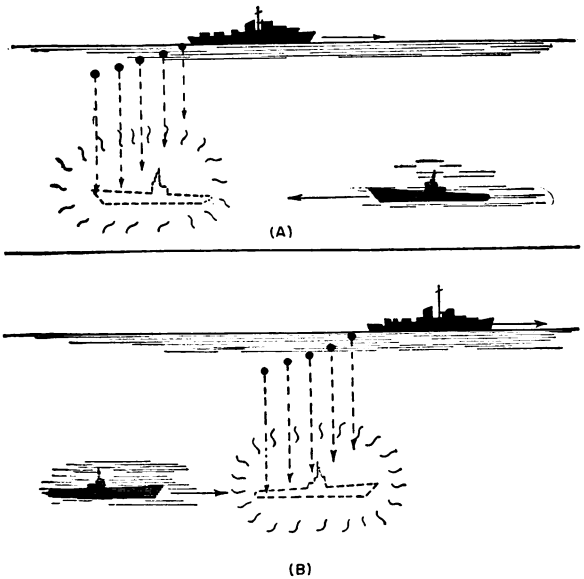

Figure 2–9.—Dropping charges ahead of the submarine.

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submarine head-on, the charges are dropped before the ship passes over the submarine. If the ship is approaching from astern of the submarine, the charges are dropped after passing over the submarine. Attacks of this type are illustrated in figure 2–9.

In both direct-bow and stern-on cases, the submarine has a good opportunity to escape by turning away. Chances of putting distance between the submarine and the depth charge pattern are better in the direct-bow attacks because ship and submarine are closing with each other at higher speeds. Aboard the submarine, Sonarmen are reporting the actions of the attacking ship. With this information, only rarely will the submarine skipper continue to move his boat along the ship's track; instead, he will turn away as shown in figure 2–10.

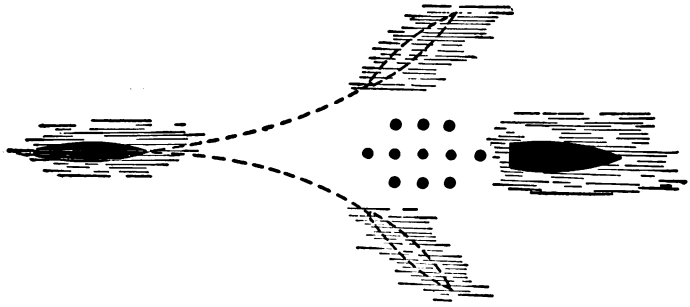

Figure 2–10.—Submarine evading.

Measures have been taken to guard against the submarine's last-minute maneuvering. Depth charges have been streamlined to increase sinking time. A charge can sink to 250 feet in about 11 seconds, and a 20-knot submarine can move 122 yards in this period. If the submariner chooses to turn sharply or to dive, the distance he covers will be even less, and not enough to get him out of range of a well-placed depth charge pattern.

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The A/S vessel's approach is also important in keeping the submarine contained. When sonar contact is made, the bow of the A/S ship is brought to the bearing of the submarine. The ship then steers a course which will take it ahead of the submarine in time to drop charges that will explode at the time the submarine reaches them. Figure 2–11 illustrates a submarine trapped by a depth charge pattern.

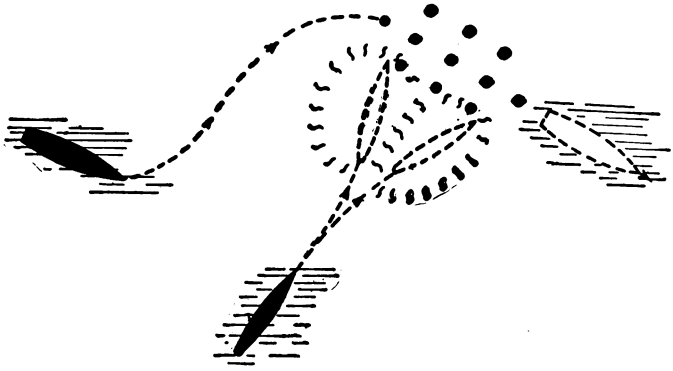

Figure 2–11.—Submarine trapped by depth charge pattern.

Allowing for lost contact at short ranges is somewhat more difficult. Lost contact ranges vary. They may be as low as 100 to 150 yards but, with poor echo-ranging conditions, contact may be lost at much greater ranges. The greater the lost contact range, the more time the submarine has to maneuver undetected. To reduce the length of this silent period and to cut down evasion time, surface vessels attack at the highest speed conditions permit. Maximum operating speed of an A/S vessel is limited because, at high speeds, water rushing past the transducer will drown out echoes from the submarine.

The most effective way of overcoming the silent period is an attack by two A/S ships. Both ships plot the submarine's position. Because there is a constant exchange of information between the ships, chances of holding con-

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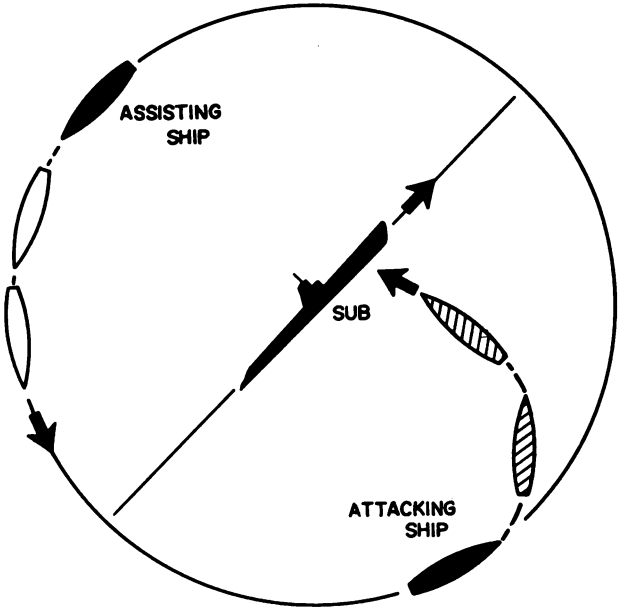

Figure 2–12.—Two A/S ships coordinating in attack.

tact are increased. One ship circles the submarine, holding contact, while the other moves in for the attack. After weapons are launched, the ship circling the submarine normally becomes the attacking ship and conducts the second attack. The ships change off until there is a sure kill. Figure 2–12 illustrates a two-ship attack on a submarine.

THROWING WEAPONS

Hedgehogs

A throwing weapon in general use today is a mortar-type projectile called the hedgehog. It has a body 7.2 inches in diameter and carries 30 pounds of TNT or 34 pounds of Torpex. It is propelled forward by gun-firing charge and explodes only on contact. In other words, it has no depth setting, and will not detonate by passing near the target—it must score a hit to explode.

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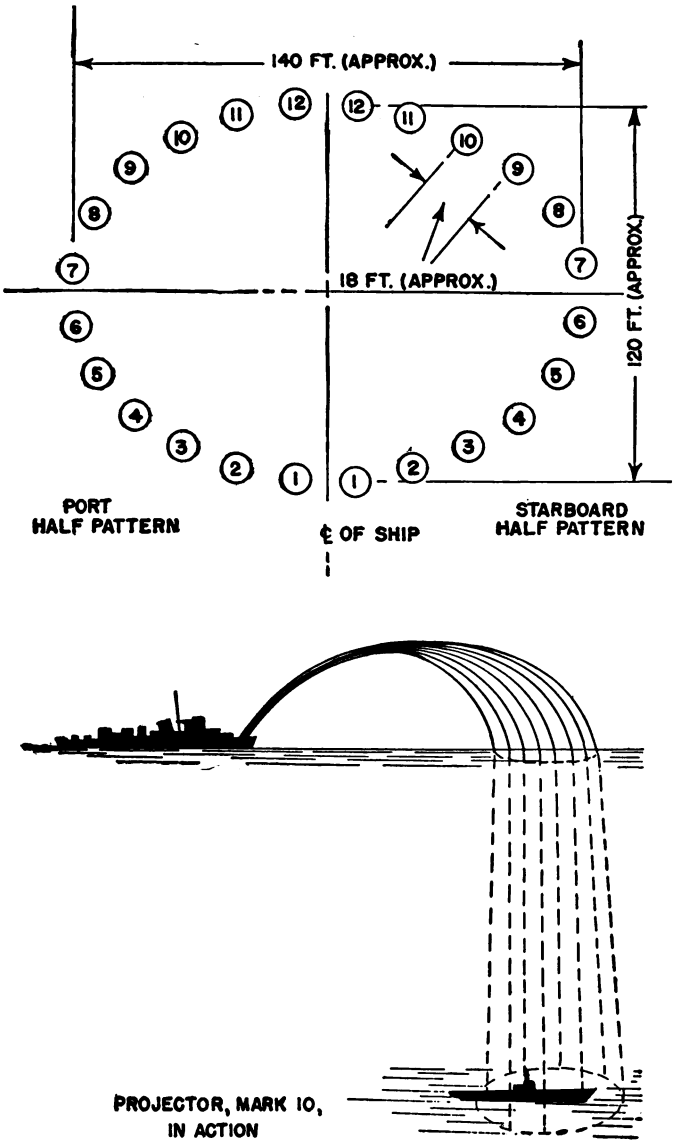

Figure 2–13.—Hedgehog in action.

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Hedgehogs are fired electrically in groups of 24 charges from each mount. Charges are fired in pairs, intervals between pairs being about one-tenth second. The 12 pairs of charges are fired in a total time of 1.0 to 1.5 seconds. In theory the pattern is a circle, but tilt may cause distortion that reduces the effective area of the pattern. Figure 2–13 shows the pattern of fall. See OP 1925 for long range hedgehogs.

For a ship to attack a submarine with hedgehogs, Sonarmen must hold sound contact with the submarine, supplying ranges and bearings. Ranges and bearings are converted to target motion by fire control instruments which indicate the course along which the ship must be steered and the time when weapons must be launched to score a hit.

In ships without fire control equipment, the conning officer conducts the attack based on the information supplied by sonar and the tactical range recorder operators. He heads the ship toward the submarine until the direction of the submarine movement is definitely established. Based on the bearing movement and the ship's position in reference to the submarine, the conning officer directs the ship to the proper attack course. Because the charges have a fixed range, the pattern must be launched when the ship reaches the correct firing range. Correct firing range depends on many factors, as own ship's speed, range rate, target motion, and so on—factors which you will study in detail as this course progresses.

Figure 2–14 shows loading operations for the Mk 15 mount. Note that the tail of the hedgehog is placed over a spigot, which contains a firing pin. Each row of spigots is mounted on an athwartships beam or cradle which can be tilted fore and aft. Tilting the cradles results in a slight change of elevation, which is used to compensate for roll and pitch but not to vary the range. There is a power drive for training the projector mount, and an additional elevating power drive to tilt the cradles.

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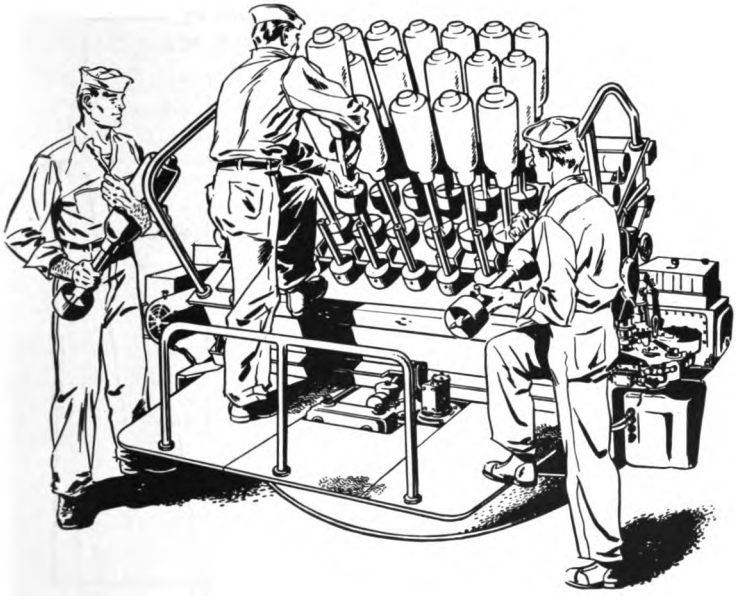

Figure 2–14.—Loading the Mk 15 mount.

The Mk 15 is a development from the older Mk 10 and Mk 11. Cradles on the older mounts are set fore and aft, and tilting these cradles produces as much as 20° of train. The salvo patterns of the Mk 10 and Mk 11 hedgehog mounts are shown for comparison in figure 2–15. See OP 1925 long range hedgehogs.

All mounts fire the same 7.2-inch hedgehog projectile. When fully loaded, all mounts hold 24 projectiles.

Hedgehogs have many advantages over depth charges. They can be launched before contact is lost at short range, thus reducing to a few seconds the submarine's maneuvering time after firing. The Mk 10 and Mk 11 mounts can be tilted to give 20° of train, and the Mk 15 provides full gun train. In practical terms this means hedgehogs can be trained and fired while your ship is still coming about to the best attack course. Finally, if

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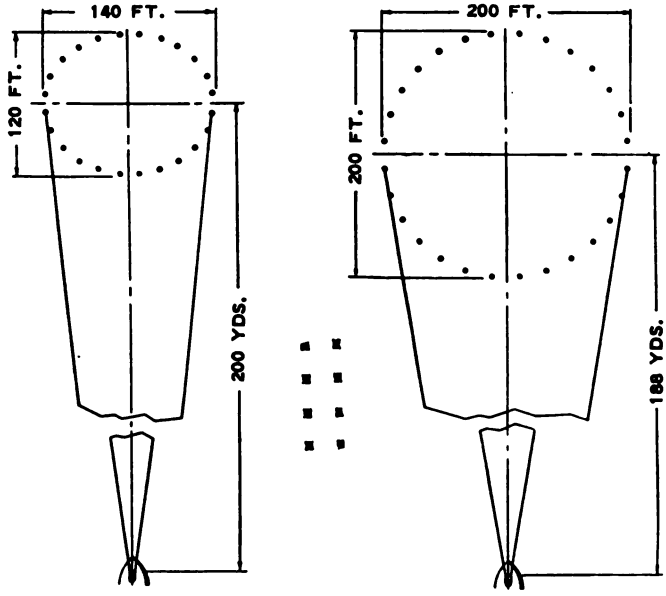

Figure 2–15.—Salvo patterns of hedgehog mounts. Left, Mk 10; right, Mk 11.

there is no hit, there is no water disturbance to interfere with echo ranging, as may be the case with depth charges.

A/S Rocket

The 12.75-inch rocket is an antisubmarine projectile, abbreviated ASP but more popularly known as Weapon A. It is a comparatively recent A/S weapon, installed only on larger A/S ships. This projectile is a true rocket, receiving propulsion from a rocket motor. (See fig. 2–16.) It carries a heavier bursting charge than the hedgehog and can be fired at greater ranges.

Weapon A is fired from the Mk 108 rocket launcher, shown at the top of figure 2–17. The launcher magazine holds 22 rounds which are fired singly at a maximum rate of 12 rounds per minute.

When an armed rocket comes within close range of a submarine, the submarine's effect on the earth's magnetic

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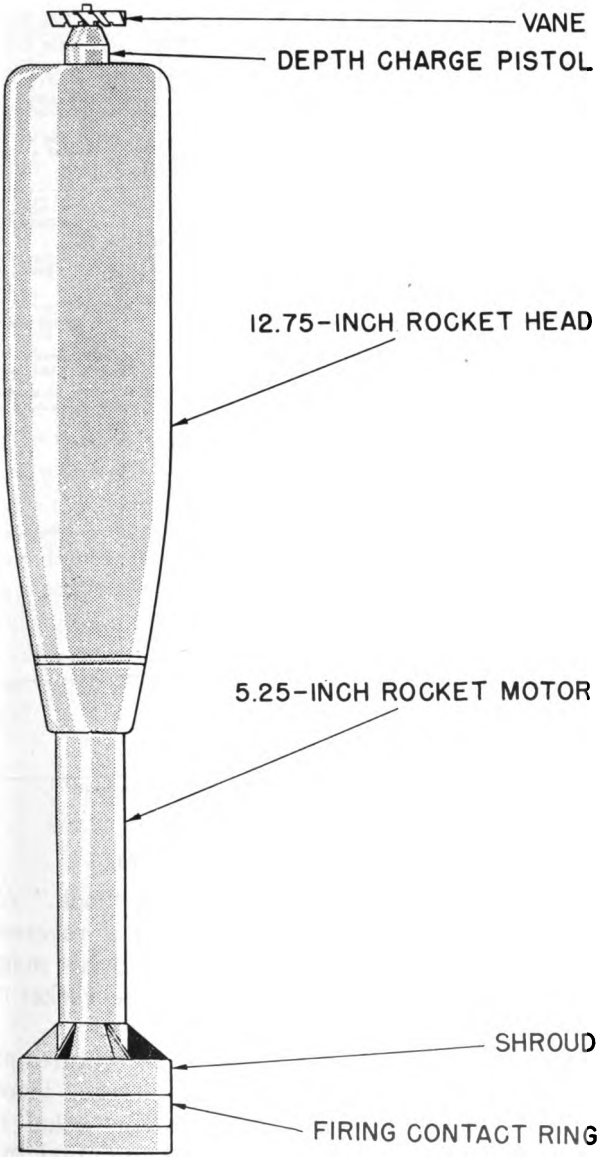

Figure 2–16.—The 12.75-inch A/S rocket.

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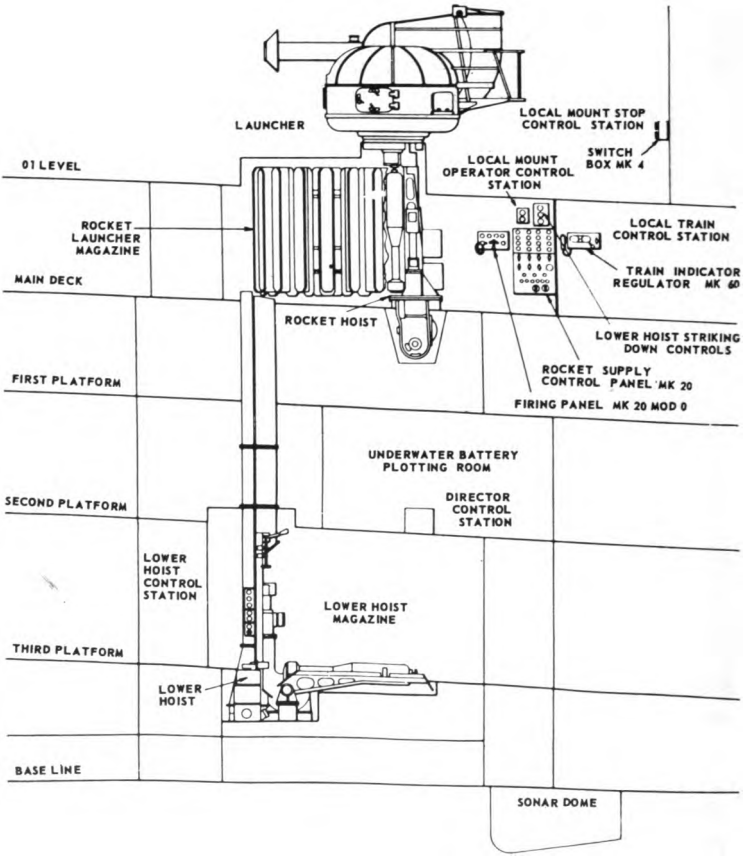

Figure 2–17.—Rocket Launcher Mk 108.

field causes the mechanism to receive a "look." As the rocket passes the submarine, it receives a reverse look produced by a reverse change in the earth's magnetic field. It is the second look that causes the rocket to explode.

The 12.75 rocket has all the desirable features of the hedgehog, plus increased explosive charge, increased range, and the ability to explode within lethal range without actual impact. Although it is not fired in patterns, as such, the rate of fire gives effective coverage.

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QUIZ

1. Who was the first American to design a submarine?
2. (a) Who invented the snorkel? (b) Who perfected it operationally?
3. What is the submarine's principal weapon?
4. Sonar equipment can be used for detection in what two ways?
5. Name the chief instrument in sonar control used for submarine detection.
6. How may you select the exact range on the sonar console?
7. What advantage does scanning sonar have over searchlight sonar?
8. What is the most important use of the tactical range recorder traces?
9. Name the three principal A/S weapons.
10. Name several advantages hedgehogs have over D/C's.
11. How many charges are fired from each hedgehog mount?
12. What advantage does the Mk 15 have over the Mk 10 or Mk 11 mount?
13. How do hedgehogs detonate?
14. How do Mk 9 depth charges detonate?
15. What type of fuze does the Mk 14 charge have?
16. What is the 12.75-inch rocket commonly called?
17. How many rounds per minute can the Mk 108 rocket launcher fire?

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CHAPTER 3

BEARINGS AND MOTION

BEARINGS ARE DIRECTIONS

When you give the BEARING of a submarine from your ship, you are telling where the submarine is located in relation to your ship. The bearing of an object is the direction of that object from your ship.

You're on a ship at sea and you contact a submarine. Because there are no landmarks at sea, you must give the bearing of the submarine from your ship with reference to a known direction. There are two known and convenient directions to use. First is the direction of true north as indicated by the compass, and second, the direction of your ship's bow. In all cases, bearings are reported in degrees read clockwise.

If you use the direction of true north, you are reporting in TRUE BEARINGS. If you use your ship's bow as a reference point, you are reporting in RELATIVE BEARINGS.

DO NOT CONFUSE BEARINGS WITH YOUR SHIP'S COURSE. The course is the direction in which your ship is moving and is read from the gyrocompass against the lubber's line. True sonar bearings are also read from the gyrocompass but they are read from the gyrocompass against the sonar cursor. The cursor indicates the true bearing to which the audio scanning switch of your equipment is responding.

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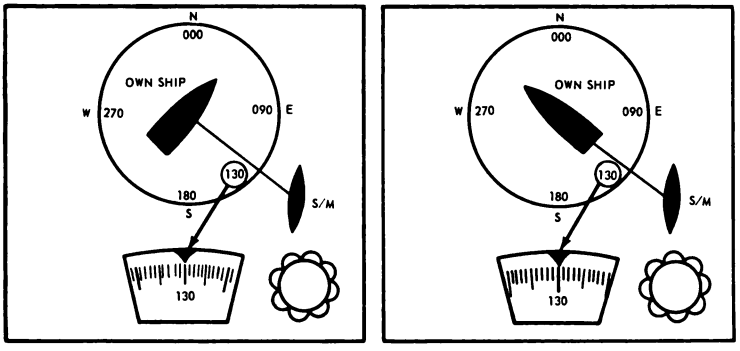
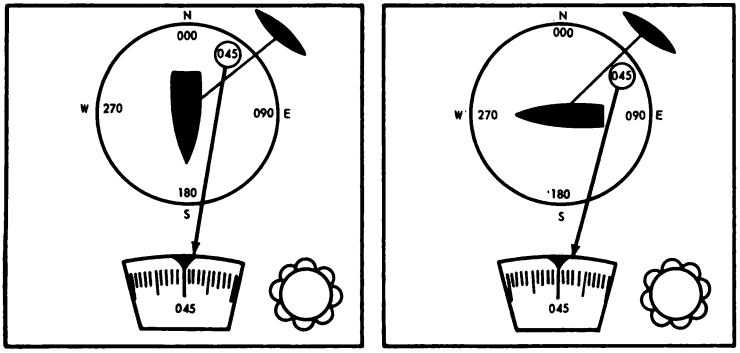
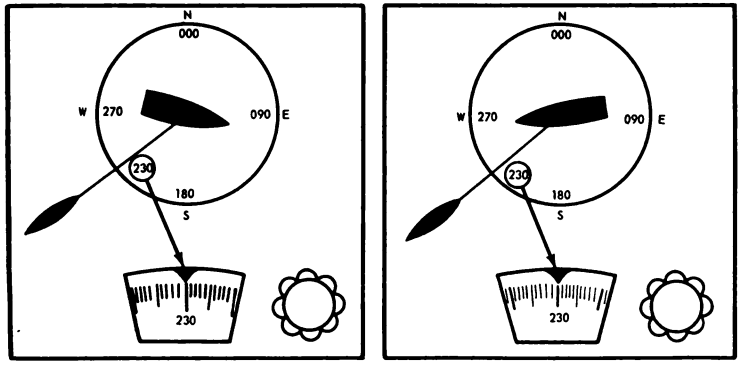


SONAR CONTACT, BEARING 130°



SONAR CONTACT, BEARING 045°



SONAR CONTACT, BEARING 230°

Figure 3–1.—True bearings are independent of ship's head.

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True Bearings

True bearings are independent of your ship's head. The left column in figure 3–1 shows three sonar contacts on different bearings. The right column shows the same contacts with the ships on different headings. In each case, true bearings of the contacts remain the same.

Always report bearings in three figures, and say ZERO instead of OH. If you contacted a submarine due south, it would bear 180° true, and you would report "Sonar contact, bearing one eight zero." You would say "Contact bearing one three zero" if you detected a submarine at 130° true.

All sonar sets include a repeater from the ship's gyrocompass arranged so that the direction of the sonar cursor is read against it to provide true target bearing. Figure 3–2 shows a sonar bearing train assembly. About 40° (that portion enclosed by dotted lines) are visible

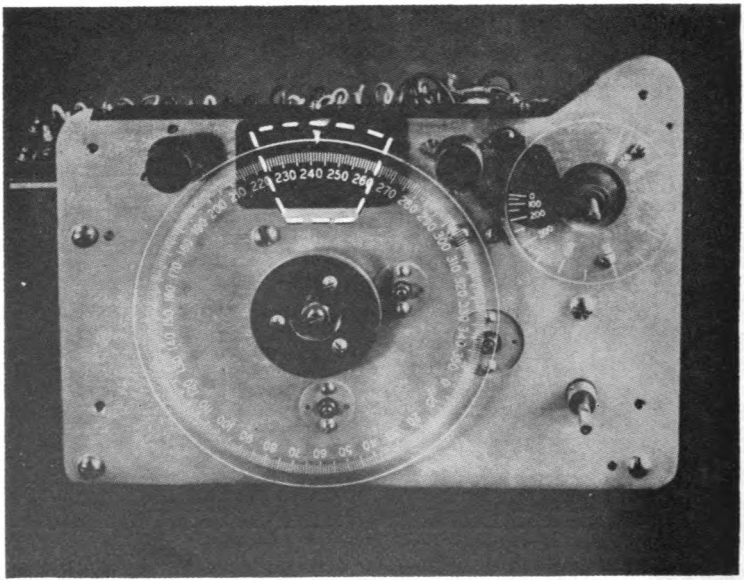

Figure 3–2.—Bearing train assembly.

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through the azimuth dial window of your console. After you have bisected the target with the cursor, you read target bearing from the azimuth dial.

True bearings are the ones you will be concerned with most frequently in sonar work because primary operating procedures are based on true bearings. You must also understand RELATIVE bearings, because you will use them if there is a casualty to the gyrocompass.

Relative Bearings

With relative bearings, it is as if the points of the compass had been painted clockwise around the ship with 000° at the bow. If a submarine is broad on your ship's port quarter, the relative bearing is 225°. If you sight a destroyer on your starboard beam, the relative bearing is 090°. Look at figure 3–3 for an illustration of relative bearings.

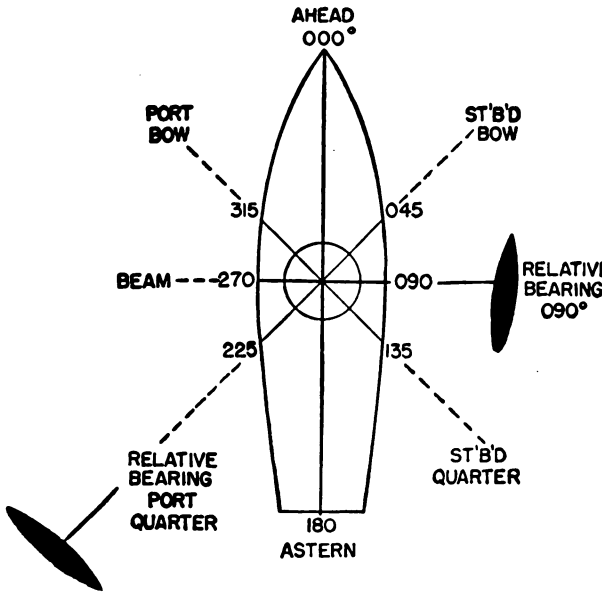

Figure 3–3.—Read clockwise from the bow.

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The bow of your ship is always 000° when you are reporting in relative bearings. When your ship turns, then, the relative bearing of a target from your ship will change (rapidly, if target is in close). In figure 3–4, as the ship turns to the right, the relative bearing of the target changes from 090° to 030°.

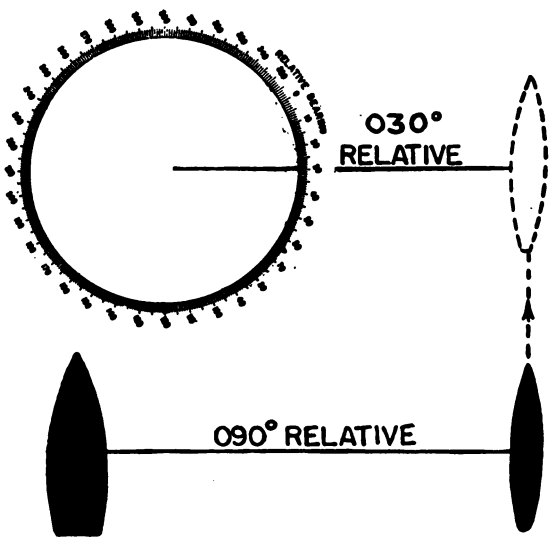

Figure 3–4.—Relative bearings change rapidly.

Relative bearings are read on the console from the same dial as true bearings. Immediately upon gyro failure, this dial begins indicating relative bearings. This feature is not available on older, searchlight-type equipments. Older sonar sets are equipped with standard gyro repeaters similar to the type you steered by when you stood wheel watches. An inner bearing ring provides true bearings, and an outer FIXED bearing ring indicates relative bearings. (Look at fig. 3–5.) Between bearing rings, a diamond-shaped "bug" moves as you move the

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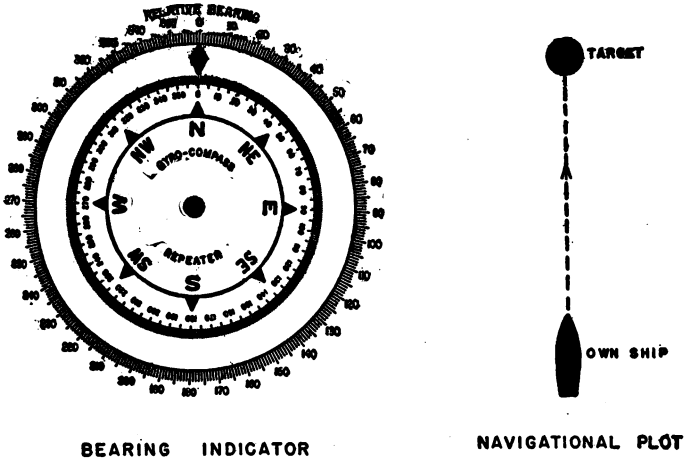

Figure 3–5.—Gyro repeater on searchlight-type sonars.

training handwheel. You read true bearings on the inner circle against the bug, and relative bearings on the outer circle against the bug.

Conversion of True and Relative Bearings

If you know own ship's course and the relative bearing of the target, you can easily get the true bearing. Suppose that the relative bearing is 090° or broad on the starboard beam, and that your ship's course is 180° true or due south. You can see that the true bearing of the target is 270° or due west. You get this by adding the relative bearing of the target with own ship's true course or heading to get true bearing.

But suppose the submarine is broad on the port beam or 270° relative. Your ship's course is still 180° true or due south. Again it is easy to see that the submarine must bear due east or 090° true. If you add the true course and relative bearing you get 180°+270°=450°. You then have a bearing greater than 360°. This is just as impossible as it is to have more than 60 minutes in an hour. When a bearing is greater than 360° you must

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subtract 360° from the total. This gives the bearing you are trying to find. In this case you must subtract 360° from 450° to get the true bearing, 090°.

Here are rules that will aid in changing relative bearings into true bearings:

TARGET RELATIVE BEARING + OWN SHIP'S COURSE = TARGET TRUE BEARING.

If true bearing is greater than 360°:

TARGET RELATIVE BEARING + OWN SHIP'S COURSE — 360° = TARGET TRUE BEARING.

If you know your ship's course and target TRUE BEARING, you can work backward to find the target relative bearing. Subtract ship's course from true bearing and you will have the relative bearing. If the true bearing is less than the ship's course, add 360° to the true bearing before subtracting the course. For instance, suppose true bearing is 045° and ship's course is 270°. Because true bearing is less than ship's course, you must add 360°. This gives 405°. Subtract ship's course (270°) from this figure, and you have the relative bearing (405° — 270° = 135°).

TARGET TRUE BEARING — OWN SHIP'S COURSE = TARGET RELATIVE BEARING.

Or, if true bearing is less than ship's course:

TARGET TRUE BEARING + 360° — OWN SHIP'S COURSE = TARGET RELATIVE BEARING.

Stern Line Indicator

Sitting before the sonar console, you have a better picture of action between your ship and a submarine than any rating aboard ship. The cathode-ray scope gives the visual picture, and audio information comes in along the bearing of the cursor. You will know when your ship changes course by movement of the STERN LINE INDICATOR. This is a dotted cursor that appears on the sonar scope and, as the name implies, indicates the direction of the ship's stern. It would be easier to interpret ship movement

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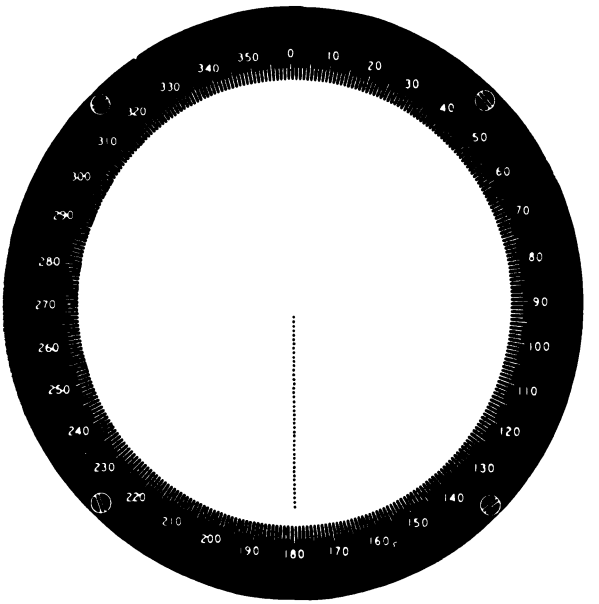

Figure 3–6.—The stern line indicator.

if this line indicated the direction of the bow. But, because most underwater information comes from forward, an additional indicator in that direction would clutter the scope unnecessarily. The bearing of the stern line is true with gyro on and relative with gyro off. With a casualty to the gyro, the stern line moves to 180° relative (see fig. 3–6), and remains there as long as you are on relative bearings.

In the normal condition, with gyro operating, ship movement does not alter the picture on the sonar scope. Only the movement of the stern line indicator tells you when the ship has changed course. When the ship puts on right rudder, the stern line moves left, just as the ship's stern goes left when the bow goes right. If you are trained on target, the cursor will remain on target through a small course change. If the ship maneuvers radically, you may

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need to adjust the cursor slightly because target bearing will change due to relative motion.

When you stood wheel watches you were aware that a ship in a turn rotated under the compass card, and the compass continued to point steadily north. This principle applies in sonar. The ship rotates under the sonar scope and the underwater picture remains oriented to true north. (See fig. 3–1 again.)

WHEN GYRO FAILS

The top of the sonar scope is always 000°. When the gyro is operating, the top of the scope indicates true north; with the gyro out, the top of the scope becomes 000° relative (that is, ship's head). Your first indication of a gyro casualty will be the lighting of the red GYRO OFF light. At the same time the stern line indicator will move to 180° relative where it will remain as long as the gyro is out. If the ship is headed for a target when the gyro fails, the target pip will move to 000° relative and will remain there as long as the ship continues to head for the target. Thus, the ship may be heading for a target bearing 090° true. On your scope the submarine is located to the right of center (toward 3 o'clock), as shown in part A of figure 3–7. The stern line is at 270°. With a gyro casualty, the target pip would move counterclockwise 90°, and the stern line would move an equal amount in the same direction, as shown in part B of figure 3–7. To remain on target, you would have to train the cursor counterclockwise 90°.

ATTACKING A SUB

Here is a simplified picture of an attack on a submarine. It will give you an idea of how the pip moves on the scope and how you will use the cursor.

When you detect an underwater target, the conning officer in most cases will swing the ship about and head for the contact. As the ship comes about, you will keep the

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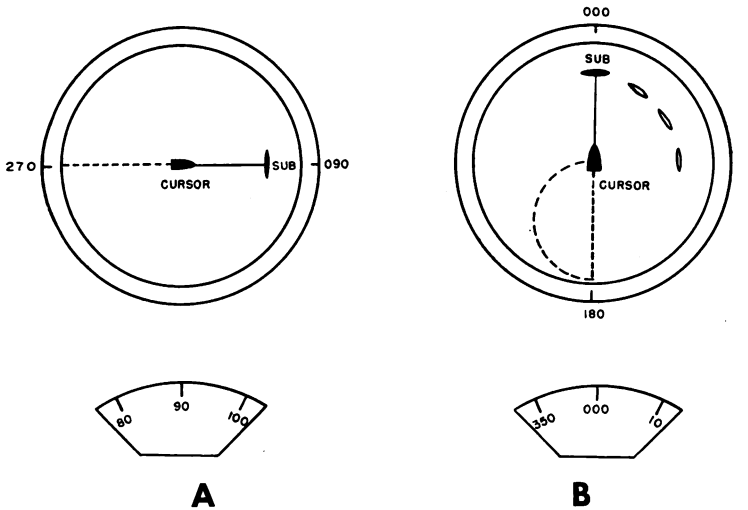

Figure 3–7.—The picture changes with a shift to relative bearings.

cursor trained on target. Once the ship is steady on, any change in target bearing will be caused by the submarine's movement through the water. Your job is to keep the pip bisected. If the submarine moves left, you train the cursor left to remain on target, and report that bearings are DRIFTING LEFT. If the submarine is moving right, you train the cursor right and report that bearings are DRIFTING RIGHT.

Chances are good that a submarine will not stay on a straight course but will maneuver to try to evade your ship. To launch weapons where they will do the most damage to the submarine, your ship will have to change course several times. Regardless of your ship's movements and the submarine's maneuvers, you must keep the cursor trained on the target. Even though the contact is visible on the scope at all times, the information you report won't be accurate unless you bisect the pip. NEVER FORGET: The primary source of underwater information is the audible echo, and you hear echoes only when the cursor is trained on target.

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Once the conning officer has determined submarine movement, he will point the bow of the ship ahead of the pip to intercept the target. In a depth charge attack, he will conn the ship to a point well AHEAD of the submarine to allow time for charges to sink to target depth. This is called TAKING A LEAD. The conning officer will increase or decrease this lead as the attack develops, depending on the speed and maneuvers of the submarine.

Suppose you contacted a submarine bearing 090° true. Your ship swings about and heads for the target, and the stern line moves to a bearing 180° away from the target pip. The ship has steadied on 090°, but you notice the target pip is moving to the right. It is soon apparent that the target is heading due south, course approximately 180°. You move the cursor to follow the target and report: "Bearings drifting right." The conning officer changes course to the right as often as necessary to keep the ship headed for the target. When range has closed to around 700 yards, he orders a course about 20° ahead of target bearing. HE HAS TAKEN A LEAD. This puts the submarine on your port bow where it will stay for the remainder of the attack—if the submarine does not maneuver.

As the ship passes the submarine at the climax of the attack, bearings will fall aft rapidly, and you will move the cursor quickly down the left side of the scope to hold contact.

In almost every attack, your use of the cursor will follow the same routine. You detect the target and bisect it; you hold the cursor on, tracking the target while your ship and the target maneuver. At the climax, target bearings move rapidly down the side of the scope. On occasions when your ship attacks a submarine from directly astern or bow-on and the submarine holds a steady course, there will be no significant bearing change. You hold the cursor steady on the center of the echo pip and report "Bearing steady." In a properly executed attack, the target pip will

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remain within 20° to 30° of the bow until weapons are launched.

No attempt has been made here to teach you operating procedures or to tell you how to develop a contact. You will get that information in later chapters. Probably the most important thing to remember at this point is that the cursor will indicate correctly the target's movements ONLY IF YOUR SHIP IS HEADED DIRECTLY TOWARD THE SUBMARINE! When your ship isn't headed for the submarine, relative motion may be such that the cursor indicates the submarine is moving in one direction, when actually it is headed on an entirely different course.

RELATIVE MOTION

The pip fell aft rapidly when you passed the target because your bearings on the submarine fell aft rapidly. The submarine's rapid bearing change was the result of relative motion between your ship and the submarine. Relative motion is defined as the movement that takes place between two objects when one or both are moving independently. It has always been a part of your life, for you couldn't walk the streets without colliding with people if you didn't understand relative motion.

Consider, as a simple example, that you are driving a car. As you approach a crossroad, you see another car approaching the intersection from the left. You unconsciously judge the bearing and speed of that car by judging the distance from the intersection, and you can tell which car will arrive first at the intersection. If you get there first, the relative position of the other car will change rapidly as you drive through the intersection and its bearings will fall aft rapidly. Figure 3–8 will give you a clear idea of this motion.

If a circle were constructed around your car and divided into the 360° of a compass card with 000° at your radiator cap, you could watch and report the relative

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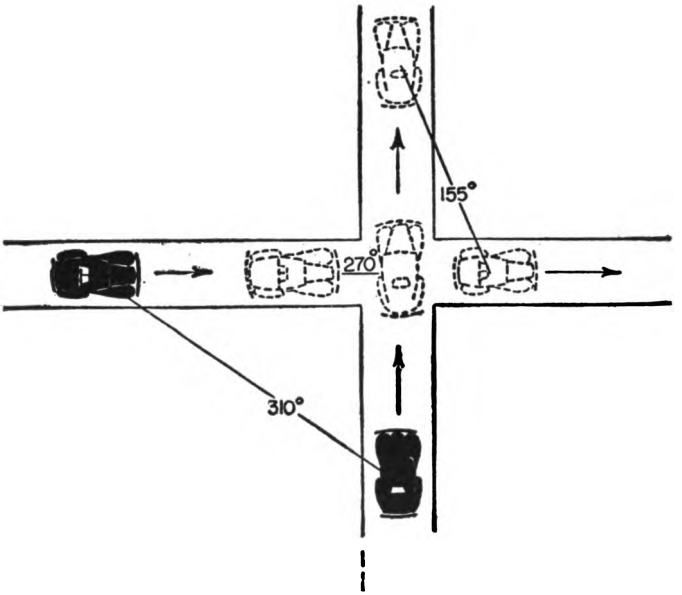

Figure 3–8.—Bearings change rapidly at short range.

bearings of the other car in relation to the relative movement of both cars. This is what happens at sea; bearings fall back or aft as you PASS another object.

Here are three rules to remember about relative motion:

1. If the bearings are drawing toward the bow, your ship will go astern of the submarine.
2. If there is no change in bearing, the ship will pass directly over the submarine. (With surface ships, this would be a collision course.)
3. If bearings are drawing aft, the ship will pass ahead of the submarine.

In depth charge attacks, the conning officer steers the ship so that it will pass AHEAD of the submarine. Figure 3–9 illustrates these three situations.

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When the conning officer orders a large course change, it takes some time to get the ship on the new course. Instead of pivoting sharply, the ship swings around in a curve.

After rudder is applied, the ship will move along on the old course for a while, gradually swinging around toward

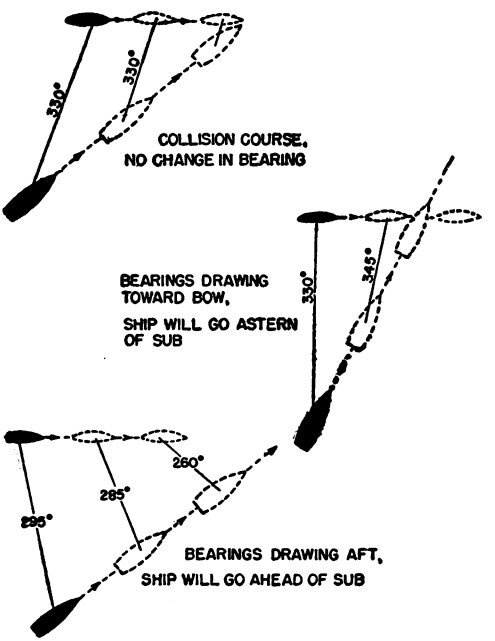

Figure 3–9.—Relative bearings between surface ship and submarine.

the new course. This distance—from the spot where rudder is applied until the ship steadies on the new course—is the ADVANCE. It's the distance forward that she must cover to make a turn.

The distance your ship moves at right angles to the original course during the advance is called the TRANSFER.

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In figure 3–10 you see an illustration of advance and transfer. Look at the left illustration. The ship is on course 000° true. If the ship holds course, she will collide with the buoy. There will be no change in bearing.

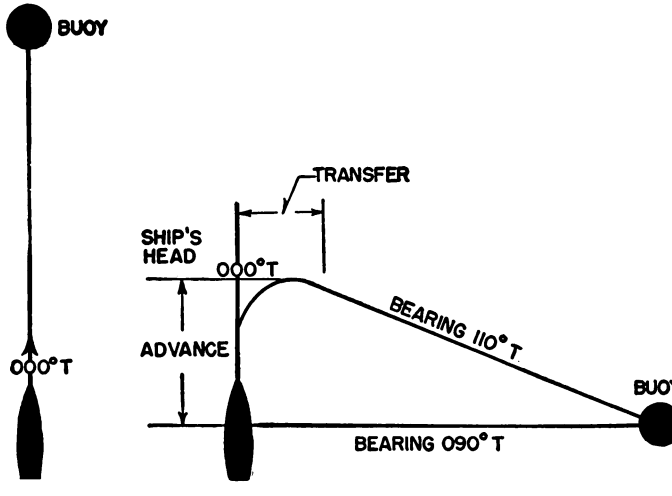

Figure 3–10.—The true bearing moves aft.

Now consider the case to the right in figure 3-10. The ship is on the same course, 000° true, but the buoy is broad on the starboard beam, or 090° true. The distance is 1000 yards. The ship turns so that she will head directly for the buoy. During the turn, the ship has altered course more than 90°. Because of the advance, the bearing of the buoy has dropped aft a bit and the buoy now bears 110° true. The ship will therefore have to come to 110° true.

Now apply this to a situation where your ship is closing with a submarine. If the submarine bears 090° true at the start of the turn, target bearing will increase slightly as the ship comes about. Because of advance and transfer, you will have to adjust the cursor slightly to stay on target as the ship turns.

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TARGET ASPECT

In antisubmarine work it is extremely important that you determine the position of the target with reference to the axis of your sound beam. Is she directly across the sound path, presenting her beam to you? Or is she moving away, presenting her stern? The position the submarine occupies within the sound beam is called the TARGET ASPECT. The terms used to describe target aspect are direct bow, bow, beam, quarter, and direct stern. If the bow of the submarine is pointing toward your ship, then you have a DIRECT BOW ASPECT. If the stern of the submarine is nearest your ship, the aspect is DIRECT STERN. Figure 3–11 illustrates these target aspects as well as bow, beam, and quarter.

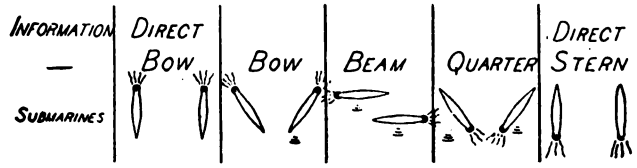

Figure 3–11.—Five target aspects.

Notice in figure 3–11 that you cannot predict bearing drift from target aspect. Bow, beam, and quarter targets may be moving either to left or right. (Of course, there would be no bearing drift with direct bow and direct stern aspects.)

If your ship changes course, target aspect will not change very much; if the target changes course, TARGET ASPECT WILL CHANGE RAPIDLY. Suppose target aspect was BOW when you made contact. This would mean that the submarine was heading for the ship. Very likely the submarine would change course immediately to attempt to get away. If the submarine turned sharply away, target aspect would change from DIRECT BOW to BOW to BEAM and perhaps even to QUARTER. Always remember, when target

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aspect changes rapidly, the submarine has changed course. Any change in the target's course will cause a change in its aspect to you.

TARGET ANGLE

Another term that applies to the position of the submarine within your sound beam is TARGET ANGLE. Target angle provides all the information you would get from target aspect and, in addition, tells you the direction in which the target is moving.

Target angle is easy to understand if you remember that it is the relative bearing of your ship from the submarine. It is as though you were standing on the submarine, using the relative bearing circle to take bearings on an attacking ship.

Imagine that you are on board a submarine looking at an oncoming destroyer. Perhaps the relative bearing of the destroyer is 090°, which means the DD is approaching on the submarine's starboard beam. As viewed from the destroyer, THE SUBMARINE'S TARGET ANGLE IS 090°, because target angle is the relative bearing of the ship from the target, measured in the horizontal from the bow of the target clockwise from 000° to 360°. It is a function of the relative positions of submarine and ship, and the controlling factor is the target's course. (You will recall that in target aspect the target's course was also the controlling factor. When the submarine changed course, target aspect changed.)

Several target angles are illustrated in figure 3–12.

You may be wondering why target aspect is important when target angle provides the same information and more of it. It is possible to report target aspect after four or five pings, based on the quality of the echo and the appearance of the echo trace on the range recorder. It takes more time to determine target angle because you must wait to determine if there is bearing drift and how

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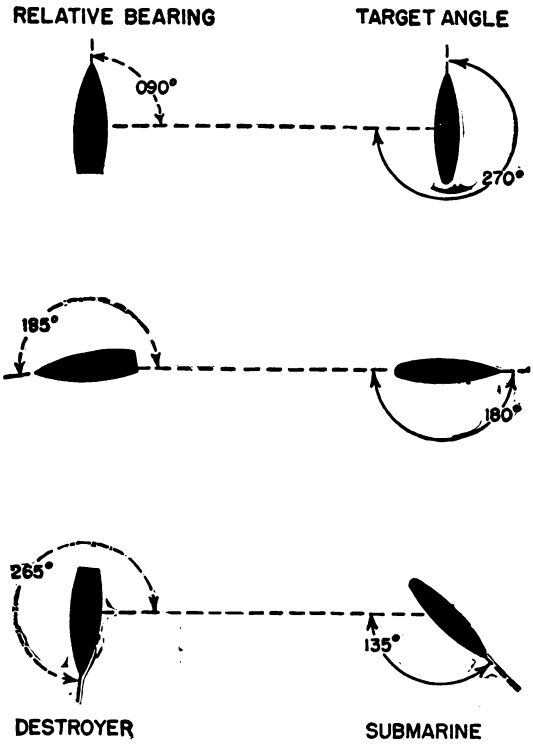

Figure 3–12.—With target angle you can compute submarine's course.

much the bearing is drifting. Also, when the submarine maneuvers radically, it may not be possible to report target angle at all. The conning officer will then receive reports of target aspect and bearing drift and from these he will estimate target angle.

There is little time between detection and attack in antisubmarine warfare. Target aspect is a means of reporting reliable information quickly.

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QUIZ

1. What is a true bearing?

2. What is the true bearing in the following examples?

	COURSE	RELATIVE BEARING
(a)	186°	270°
(b)	251°	027°
(c)	350°	295°
(d)	260°	190°

3. What is the relative bearing, with course and true bearing given?

	COURSE	TRUE BEARING
(a)	072°	289°
(b)	350°	071°
(c)	175°	275°
(d)	256°	255°

4. What is the ship's course?

	RELATIVE BEARING	TRUE BEARING
(a)	241°	350°
(b)	037°	151°
(c)	350°	031°
(d)	070°	021°

5. Give the approximate target angle for the following aspects:
   (a) Direct bow.
   (b) Quarter target moving right.
   (c) Bow target moving left.
   (d) Beam target moving left.

6. If you made contact with a submarine on your port bow, your course 000°, submarine's course 090, how would the relative bearings change during a depth charge attack?

7. What part does the cursor play on the cathode-ray scope?

8. On scanning sonar, what is the first indication of a gyro failure?

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CHAPTER 4

UNDERWATER SOUND

IT'S DONE WITH SOUND

A submarine under water can hide from everything but sound—sound projected or "bounced" off its hull, giving a returning echo; or the sound made by its own screws, auxiliary machinery, and so forth. Some destroyers carry special listening gear, and, of course, all submarine Sonarmen have long known the importance of listening to the sound output of surface craft and other submarines. In this chapter we are interested only in echo ranging, which tells the Sonarman that a submarine is in nearby waters. The methods and equipment used by submarine sonar operators are discussed in *Sonarman 3 and 2, Volume 2.*

Use of the entire sonar equipment depends on this one sound, the echo from a target. Is that target a submarine? Has the sound beam struck a submarine, or could it be a wake? Every man on board ship is depending on you for the answer. It is the Sonarman's job to know the differences in echoes that are heard. First, REPORT ANY ECHO HEARD. Then identify that small sound as PROBABLE SUBMARINE, POSSIBLE SUBMARINE, or NONSUBMARINE.

To do this, you must understand what sound is, how it behaves in sea water, and how it enables you to contact submarines.

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WHAT SOUND IS

Sound is the physical cause of your sensation of hearing. Anything that you hear is a sound. There are also sounds that you cannot hear, and you will deal with them in sonar.

Sound travels in the form of waves. These waves vary in length. A long wavelength is heard as a low sound, and a short wavelength is heard as a high sound. A complete wavelength is called a cycle, and if the sound is below 20 cycles per second or above 15,000 cycles per second, it cannot be heard. The range between, which CAN be heard, is called the AUDIBLE RANGE, and the sounds heard are known as SONICS. Sounds below this range (below 20 cycles) are SUBSONICS; those above (above 15,000 cycles) are ULTRASONICS. The sound beam sent out by the sonar transducer is made up of ultrasonic waves. The sonar receiver changes these ultrasonic sounds into sonics so they can be heard.

Source—Medium—Detector

Remember how you were awakened every morning by the bugle call in boot camp? The bugle acted as the sound SOURCE, air was the MEDIUM for carrying the sound, and your ears acted as the sound DETECTOR. These are the three basic elements of sound: the source, the medium, and the detector. All three must be present before there is a sound.

Look at figure 4–1. The bell vibrates on being struck, acting as a sound source. The vibrating bell moves the particles of air—the medium—in contact with it. And the sound waves travel to the ear, which acts as the detector.

Anything which moves rapidly to and fro, or vibrates and thus disturbs the medium around it, may become a sound source. Bells, radio loudspeaker diaphragms, and stringed instruments are familiar sound sources.

Sound waves are passed along by the particles of the material through which they travel. Therefore, a material substance, a medium, is necessary to transmit sound

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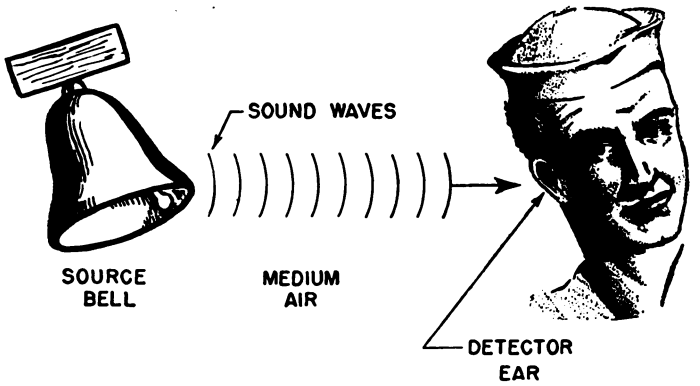

Figure 4–1.—The three elements of sound.

waves. A sound medium is any material substance through which sound energy will travel. It may be a gas (such as air), a liquid (water), or a solid (steel). The medium must be something material, with body and substance to it, or the sound will not be transmitted. Sound will not travel through a vacuum. In sonar, you are interested in the liquid medium—water.

The detector acts as the receiver of the sound wave. Yet, since it does not surround the source of the sound wave, it absorbs only PART of the energy of the sound wave from the medium. This absorbed energy is converted, in the case of the human ear, into an impulse that travels to the brain. Electrical devices, such as microphones, also detect sound waves and convert them into electrical impulses.

THE WATER WAVE

Throw a stone into a pool. A series of circular waves travel away from the disturbance. In figure 4–2 such waves are diagrammed as though seen in cross section—from the side, with the front portion cut away.

Observe that water waves are a succession of CRESTS and TROUGHS. The WAVELENGTH is the distance from the crest of one wave to the crest of the next wave. Water

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waves are known as TRANSVERSE waves because the motion of the water molecules is up and down, at right angles to the direction in which waves are traveling. A cork on the water bobs up and down as waves pass by.

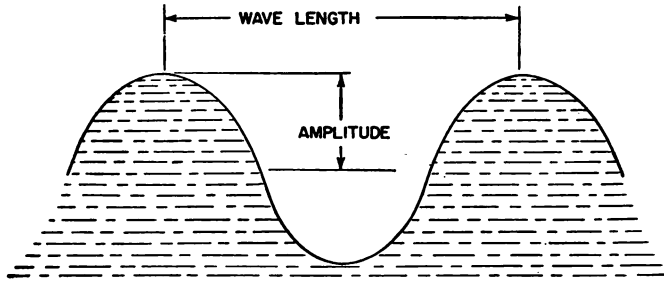

Figure 4–2.—Transverse water wave.

The AMPLITUDE of a transverse wave is HALF the distance, measured vertically, from crest to trough, and serves to indicate the INTENSITY or VIOLENCE of the wave motion.

Sound or Longitudinal Waves

Sound waves are LONGITUDINAL or COMPRESSION waves, set up by some vibrating object, such as the sonar transducer. In its forward movement, the vibrating transducer pushes the water particles lying against it, producing an area of high pressure.

Water is elastic. So, on the backward movement of the transducer, water particles move apart to produce an area of low pressure, or a RAREFACTION. Next, the particles in the first compression expand, and push the water particles immediately in front of them, thus causing a second compression farther out.

This action goes on and on, and sets up a spreading series of compressions and rarefactions. In figure 4–3 the compressions are represented by dark rings. As the sound waves spread out, their energy at the same time is spread

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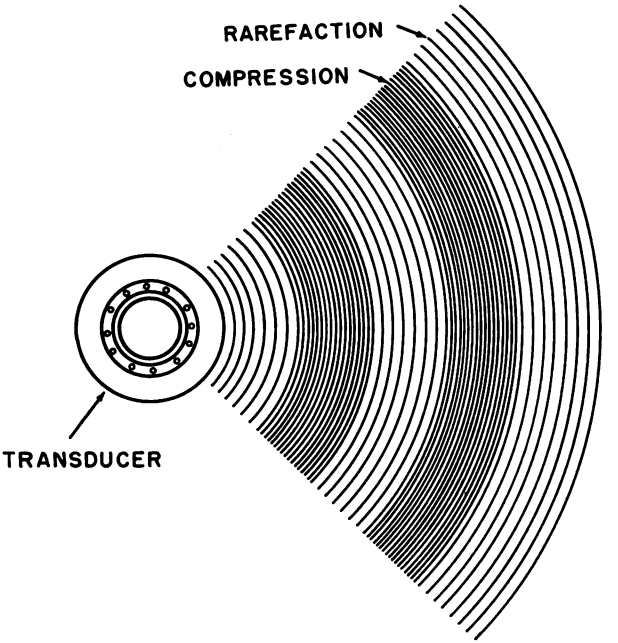

Figure 4–3.—The longitudinal sound wave.

through an increasingly large area, and the wave motion at a distance is weaker.

The wavelength is the distance from one point along the wave to the next point of similar compression. Amplitude is ONE-HALF the distance through which the vibrating source of the sound waves moves. The greater the amplitude, the greater the intensity or loudness of the sound.

Another way of presenting the actions of the sound wave is illustrated in figure 4–4. The compressions are drawn as hills above the reference line, and the rarefactions as valleys below it. Thus, a wavelength is the distance between points where the same pressure conditions exist: for example, between the crests or between the troughs. A CYCLE is one complete set of changes, starting from the reference line, descending to a low point, mounting to a high point, and returning to the reference line.

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Think of a cycle in this way: Imagine being a series of roller coaster hills all equal in size. The cycle starts when you are halfway down one hill, continues as you go up the next hill, and ends when you are halfway down that hill. Wavelengths and cycles are illustrated in figure 4–4.

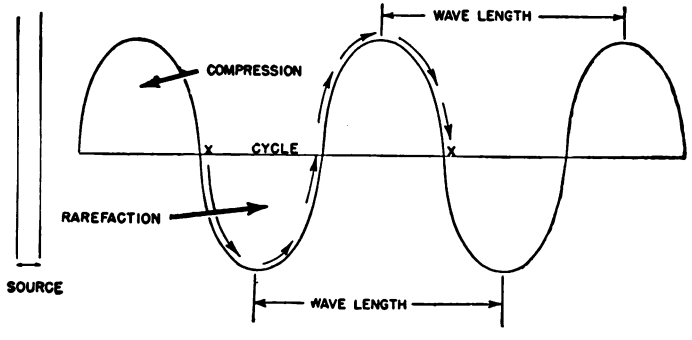

Figure 4–4.—In sonar, a wavelength varies with frequency.

The FREQUENCY of the wave is the number of cycles per second. In the motion of the sound wave through the medium, the particles of the medium move back and forth in a limited space, passing the wave along, as it were. The wave, however, may travel great distances and with high speed.

Sound waves can be sent through all gases, liquids, and solids, but NOT through a vacuum, because there are no particles in a vacuum to be subjected to alternate compression and rarefaction.

In different substances, sound travels at different speeds. In air, velocity (speed) of sound is about 1090 feet per second at 32° F. For each 1° rise in Fahrenheit temperature, velocity is increased by 1.1 feet per second. For instance, in air of 72° F., sound travels at the rate of 1090 + (72—32) x 1.1, or 1090 + 44 = 1134 feet per second.

In pure water, velocity of sound is approximately 4708 feet per second. In sea water, velocity depends on salt con-

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tent (salinity), pressure, and temperature. For all practical purposes, it's safe to assume that sound travels at a speed of 4800 feet per second in sea water of 39° F.

WAVELENGTH = VELOCITY/FREQUENCY

If a sonar transducer vibrates at the rate of 25,000 vibrations per second, and if the temperature is 39° F., the first wave will be 4800 feet away at the end of the first second. Between the transducer and this wave there will be 25,000 other compressions. Thus the wavelength, that is the distance between points of similar compression, must be 4800÷25,000, or 0.149 foot, because there are 25,000 compressions extending through a distance of 4800 feet. The wavelength always can be found if the frequency and the velocity are known.

$$\text{FORMULA: Wavelength} = \frac{\text{velocity}}{\text{frequency}}.$$

Now suppose that the wavelength is 0.4 foot and the frequency is 12,000 cycles per second. What is the velocity?

$$0.4 = \frac{\text{velocity}}{12{,}000}; \text{ or,}$$

$$\text{velocity} = 0.4 \times 12{,}000 = 4800 \text{ feet per second.}$$

Similarly, if the wavelength and the velocity are known, the frequency can be found.

$$0.4 = \frac{4800}{\text{frequency}}; \text{ or,}$$

$$\text{frequency} = 4800 \div 0.4 = 12{,}000 \text{ cycles per second.}$$

CHARACTERISTICS OF SOUND

The explosion of shells in a barrage causes NOISE; that is, the sound has so many instantaneous sources that it has no regular pattern of vibrations.

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A MUSICAL NOTE has a pattern of regular vibrations. Such a sound has three characteristics: PITCH, INTENSITY (loudness), and QUALITY. An object that vibrates many times per second produces a sound with a HIGH pitch, as in the instance of a whistle. The slower vibration of the heavier wires within a piano causes a LOW-pitched sound. Thus the FREQUENCY of vibrations determines pitch. When the frequency is low, sound waves are long; and when it is high, the waves are short. Velocity is not affected by pitch. Otherwise, at a distance of only a few dozen feet from an orchestra, would be heard a dismal jumble of sound waves all out of step. Sounds whose frequencies lie between 20 and 15,000 vibrations per second are audible and are called the SONICS.

You control the loudness, or INTENSITY, by controlling the AMPLITUDE. You can produce a weak sound by a loudspeaker cone, and feel the slight vibration by touching the cone with a fingertip. Increase the loudness of the sound, and note the much greater movement of the cone though the rate of vibration is not increased.

A voice can be recognized by its quality, which depends upon complicated wave forms created by the combination of several different types of sound waves. A tone can be built up to any desired quality by combining pure tones in suitable proportions. Sound together just the right organ pipes, and any vowel sound can be imitated. Two notes of the same pitch played on different musical instruments differ in quality because lesser vibrations are superimposed upon the FUNDAMENTAL vibration. The fundamental is the vibration with the lowest frequency.

THE SOUND BEAM

Now that you know what sound waves are in general, you can begin to think about sound waves in particular. The particular sound waves of interest to Sonarmen are the waves that leave the sonar transducer in the form of a beam and go out into the water in search of a submarine.

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If the sound beam finds a target, it will return in the form of an echo.

The use of sonar equipment depends on the presence and the recognition of an echo from a target. Detection of the echo depends on the quality and relative strength (loudness) of the echo compared to the strength and character of other sounds which tend to mask it.

It is important for Sonarmen to know what things can weaken the sound beam as it travels through water, what factors in the sea water determine the path and speed of the sound beam, and what things affect the strength and character of the echo.

When the sound beam travels through water, it encounters hazards of travel which will WEAKEN it or reduce its strength. Any signal strength lost in this manner is known as a TRANSMISSION LOSS.

Absorption

Some of the sound is ABSORBED in passing through water. The amount of sound lost this way depends on the state of the sea. Absorption is high when winds are great enough to produce whitecaps and cause a concentration of bubbles in the surface layer of the water. Absorption is also much greater in wakes and strong currents, such as riptides. Echo ranging through wakes and riptides is therefore difficult, owing to the combined effects of false echoes, high reverberations, and increased absorption. Absorption is greater at high frequencies than at low frequencies.

Scattering

Sound waves are weakened when they reach a region of sea water that contains foreign matter, such as seaweed, silt, animal life, or air bubbles. This foreign matter SCATTERS the sound beam and causes loss of sound energy. The practical result of scattering is to reduce echo strength, especially at long range.

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Echoes occur when sound strikes an object or a boundary in such a manner as to REFLECT the sound or to throw it back to its origin. You've probably stood in a tunnel and yelled, "Hello!" just to hear the echo of your voice. Your voice sent sound waves out through the medium of the air. When these waves reached an object of different density (the side of the tunnel), some of them were reflected back, and the echo was heard.

The same thing happens when sound strikes a metallic object like a submarine. Sound waves sent out by the sonar transducer hit the submarine, and some of the sound waves are reflected back as an echo. This echo is picked up by the transducer and delivered to your ears.

Reflection of sound waves occurs when there is a difference in the density or wave velocity (speed) in the two mediums. For instance, a sound wave traveling through sea water is almost entirely reflected at the boundary (sea surface) between the water and the air. The speed of sound in sea water is about four times greater than that of sound in air, and the density of the water is more than 800 times greater than that of air. Therefore, all of the sound beam will be reflected downward from the sea surface.

Similarly, when a sound wave traveling through sea water strikes a solid object like a submarine, the difference in the density and sound velocity in the two mediums is such that all but a small part of the sound beam is reflected. That portion of the beam which strikes surfaces of the submarine PERPENDICULAR to the beam will be reflected directly as an echo. Look at figure 4–5 for a pictorial explanation of this.

When the sea surface is smooth, the sound may be reflected from the surface. This effect disappears as the sea becomes rough and the sound is scattered. In water less than 600 feet deep, the sound may also be reflected from the bottom. Other factors being equal, the transmission

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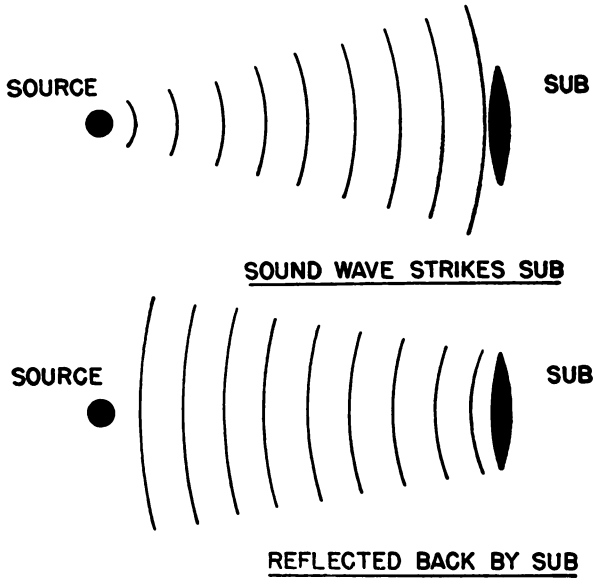

Figure 4–5.—Part of the sound comes back.

loss will be least over a smooth sand bottom and greatest over soft mud. Over rough and rocky bottoms, the sound is scattered, resulting in strong bottom reverberations.

Reverberations

When sound echoes and re-echoes in a large hall, the sound REVERBERATES. Reverberations are multiple reflections. Here's an example of this in nature: A discharge of lightning causes a quick sharp sound, but by the time the sound of the thunder is heard, it is usually drawn out into a prolonged roar by reverberation.

A similar case often arises in connection with sonar. Sound waves often strike small objects, such as fish or air bubbles, in the sea. These small objects cause the waves to scatter. Each object produces a small echo which may return to the transducer. The reflections of sound waves from the sea surface and the sea bottom also create echoes.

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The combined echoes from all these disturbances are called reverberations. Since they are reflected from various ranges, they seem to be a continuous sound which is stronger at first and gradually fades away. Reverberations from nearby points may be so loud that they interfere with the returning echo from a target.

Reverberation or backward scattering of the sound wave is of three main types.

There is a reverberation from the mass of water. Causes of this type of reverberation are not completely known, although fish and other "scatterers" contribute to it.

Another type is reverberation from the surface. This is most intense immediately after the transmission goes out, then it decreases rapidly. Intensity of the reverberation increases markedly with increased roughness of the sea surface.

There also is reverberation from the bottom. In shallow water, this type of reverberation is the most intense of the three, especially over rocky and rough bottoms.

Spreading or Divergence

Just as the beam from a searchlight spreads out and becomes weaker with distance, so also does sound. The farther the target is from the sonar transducer, the weaker the sound waves will be when they reach it. This is known as spreading or divergence.

Refraction

If there were no temperature differences in the sea, the sound beam would travel in a straight line, since the speed of sound would be roughly the same at all depths. As indicated in figure 4–6, the beam of sound would spread and become weakened by absorption at a relatively constant rate. At normal search speeds in deep water, with gear in good condition, and calm to moderate seas, the maximum echo range on a submarine would almost always lie be-

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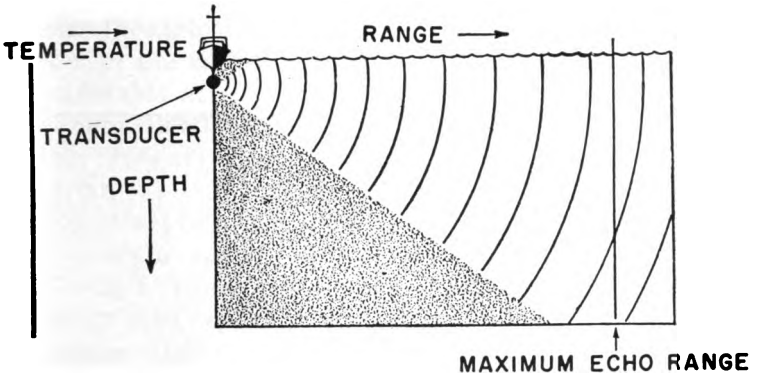

Figure 4–6.—The beam in water of constant temperature.

tween 2000 and 4000 yards, and would be independent of submarine depth.

Unfortunately, however, the speed of sound is not the same at all depths. The velocity of sound in sea water increases from 4700 feet per second to 5300 feet per second as the temperature increases from 30° to 85° F. Salinity and pressure effects on sound speed are usually not important compared to the large effects commonly produced by temperature changes in the sea. BECAUSE OF THE VARYING TEMPERATURE DIFFERENCES IN THE SEA, the sound beam does not travel in a straight line but follows curved paths. This results in bending, splitting, and distortion of the sound beam.

When the beam of sound is bent, it is said to be REFRACTED. A sound beam is bent or refracted when it passes from one medium in which its speed is high (such as warm water) into one in which its speed is low (such as cool water). A SOUND BEAM WILL BEND AWAY FROM LEVELS OF HIGH TEMPERATURE AND HIGH SOUND VELOCITY AND TOWARD LEVELS OF LOW TEMPERATURE AND LOW SOUND VELOCITY. Figure 4–7 gives a better idea of this phenomena called refraction.

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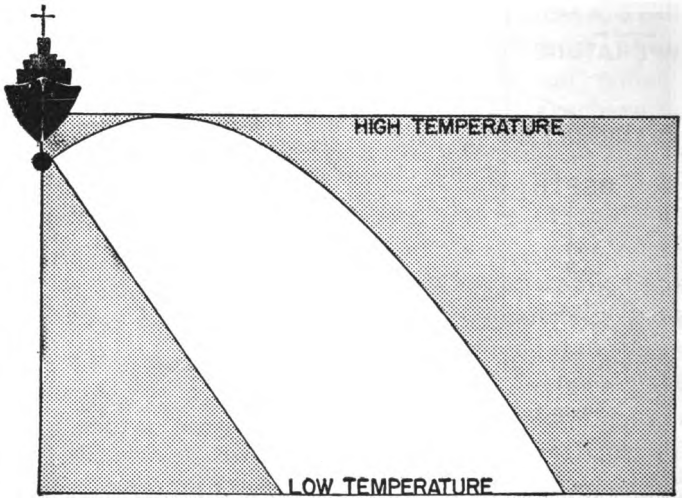

Figure 4–7.—Bending limits the range.

As a result of refraction, the range at which a submarine can be detected by sound may be reduced to less than 1000 yards, and this range may change sharply with changing submarine depth.

THREE FACTORS

The three main characteristics of sea water that influence the speed with which the sound beam travels through the water are—

1. SALINITY, or the amount of salt in the water.
2. PRESSURE, caused by increased depth.
3. TEMPERATURE, which takes the form of slopes, or gradients.

Sea water has a high mineral content. The density of sea water is about 64 pounds per cubic foot while that of fresh water is about 62.4 pounds per cubic foot. This is the result of the salt content in the sea water. Salt content is spoken of as the SALINITY of the water.

The over-all effect of increasing the salinity is to increase the SPEED of the sound. This means that when sound

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passes through water which varies in salinity, it travels faster in the saltier water. Such a change in salinity is considerable at the mouths of rivers emptying into the sea. Elsewhere the difference in salinity is too small to bother the rate of travel of the sound beam, and may be ignored.

Sound travels faster in water under pressure. The deeper sound goes in the sea, the higher the pressure on that water. Therefore, the speed of sound in the sea INCREASES with depth. This effect is also rather small.

Temperature is by far the most important of the factors affecting the speed of sound in water. The speed of sound will increase with increasing temperature at the rate of 4 to 8 feet per second per degree change, depending on the temperature. Since the temperature of the sea varies from freezing in the polar seas to more than 85° F. in the tropics, and may decrease by more than 30° F. from the surface to a depth of 450 feet, it is clear that temperature is the most important factor. REMEMBER: THE SPEED OF SOUND INCREASES WHEN THE TEMPERATURE OF THE WATER INCREASES.

Depth and Temperature

Except at the mouths of great rivers where salinity may be a factor, the path followed by the sound beam will be determined by the pressure effect of depth and by temperature.

The pressure effect is always present and always acts in the same manner, tending to bend the sound beam UPWARD. Figure 4–8 illustrates the situation when the temperature does not change with depth. Even though the temperature does not change, the speed of the sound increases with depth, due entirely to the effect of pressure, and the sound beam bends UPWARD.

Figure 4–9 shows what happens when temperature INCREASES steadily with depth. When the surface of the sea is cooler than layers beneath it, the temperature increases with depth, and the water has a POSITIVE THERMAL GRADI-

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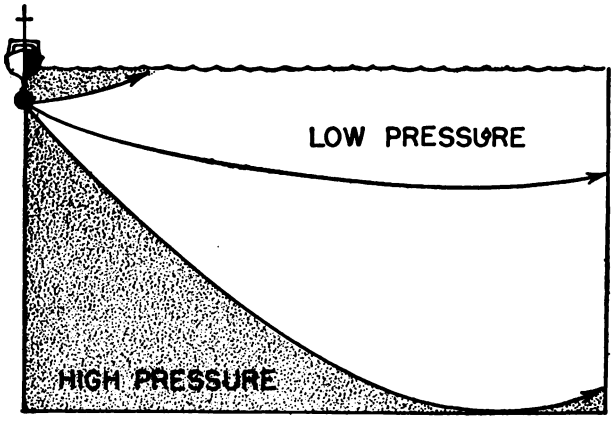
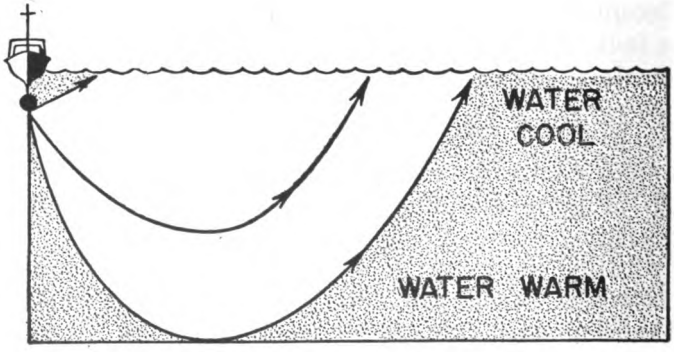
ENT. This is an unusual condition, but when it does happen it causes the sound beam to be refracted sharply UPWARD.

When the sea grows cooler as the depth INCREASES, the water is said to have a NEGATIVE THERMAL GRADIENT. Here



PRESSURE ALONE BENDS BEAM UP

Figure 4–8.—Bending away from pressure.



WHEN TEMPERATURE INCREASES WITH DEPTH, SOUND BENDS SHARPLY UP

Figure 4–9.—Short ranges on a deep sub.

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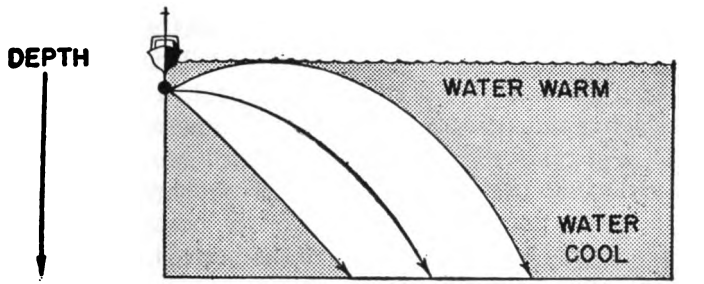
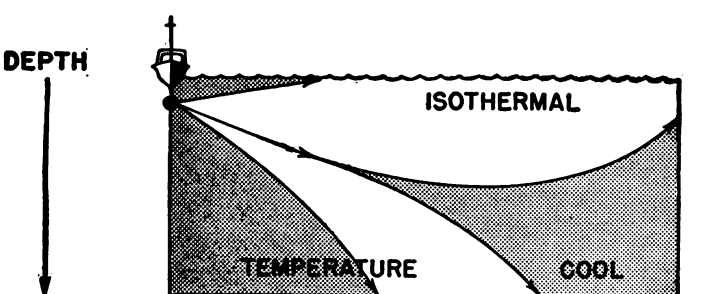
the effect of temperature greatly outweighs the effect of depth, and the sound beam is refracted DOWNWARD. This is illustrated in figure 4–10.



SOUND BENDS DOWN WHEN WATER GROWS COOLER WITH DEPTH

Figure 4–10.—Poor sound conditions.

If the temperature is the same throughout the water, the temperature gradient is ISOTHERMAL (constant temperature). Look at figure 4–11. The surface layer of water is isothermal, BUT beneath this layer the temperature decreases with depth. This causes the sound beam to SPLIT and bend UPWARD in the isothermal layer and DOWNWARD below it.



SOUND BEAM SPLITS WHEN TEMPERATURE IS UNIFORM AT SURFACE AND COOL AT BOTTOM

Figure 4–11.—Fair sound conditions.

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DON'T FORGET: WHEN NO TEMPERATURE DIFFERENCE EXISTS, THE SOUND BEAM BENDS UPWARD. WHEN THE TEMPERATURE CHANGES WITH DEPTH, THE SOUND BEAM BENDS AWAY FROM THE WARMER WATER.

Under ordinary conditions the sea has a temperature structure similar to that in figure 4–12. This temperature structure consists of three parts: First, a surface layer of varying thickness, with uniform temperature (isothermal) or a relatively slight temperature gradient; second, the THERMOCLINE, a region of relatively rapid decrease in temperature; and third, the rest of the ocean, with slowly decreasing temperature down to the bottom.

If this setup changes, the path of the sound beam through the water will change.

LAYER DEPTH is the depth from the surface to the top of a layer of sharp negative temperature gradient. Above layer depth, the temperature may be uniform, or a POSITIVE or weak NEGATIVE GRADIENT may be present.

LAYER EFFECT is the partial protection from echo-ranging and listening detection which a submarine gains when

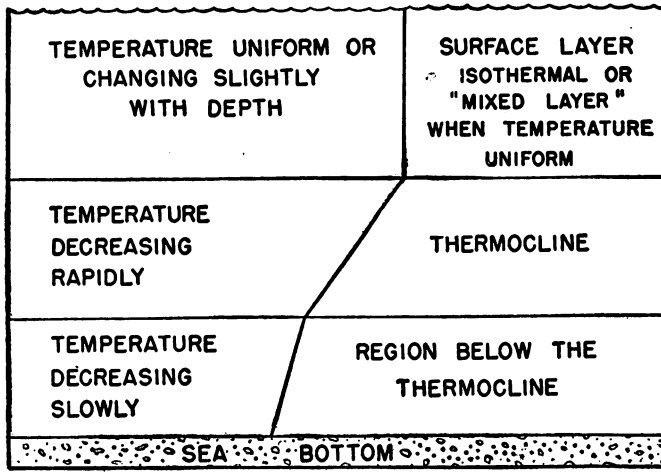

Figure 4–12.—Typical layers.

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it submerges below layer depth. Some submarine commanders have reported that, on diving through a sharp THERMOCLINE while taking evasive action, they lost the screw noises of the enemy A/S vessel, and, although they could still hear the "pinging," the signal was of low intensity, and the tactics of the enemy indicated that he had lost contact. Reports from surface vessels also indicate that ranges on submarines are greatly reduced when the submarine dives below a sharp thermocline, and that the echoes received are often weak and "mushy."

This partial protection afforded a submarine lying below a sharp thermocline is the "layer effect" just defined. Submarine commanders are aware of layer effect and make use of it in evasive tactics.

ADDED NOTES OF INTEREST

In strong winds and heavy seas, the roll and pitch of the echo-ranging ship make it difficult to keep the sound beam on the target. In addition, presence of air bubbles in the water weakens the sound beam. Sometimes this envelope of air bubbles will blanket or quench the sound sent out by the transducer. Sonarmen can tell when the sound beam has been sent out into air by the dull thudding sound that accompanies it. This is known as QUENCHING.

Echo ranging is difficult in shallow water because the sound is reflected or scattered from the bottom.

THESE ARE THE CONDITIONS FOR HEARING ECHOES:

1. Usually poor near coasts (50 miles) as compared with conditions farther out at sea. Conditions for hearing are particularly bad off the mouths of rivers.
2. Better in winter than in summer.
3. Better at night than in the middle of the day, especially in spring and summer.
4. Better in morning than in afternoon in spring and summer, but little change if whitecaps are present. In many localities, however, conditions are better in

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the afternoon than in the morning, because of the effect of prevailing winds that freshen in the afternoon.

REMEMBER: Short ranges are not necessarily the result of poor sound conditions. They may be caused by poor operating or poor adjustment of equipment. In the open sea, conditions are usually good.

LOST CONTACT!

You will be saying this phrase, "Lost contact!" when the sound beam is no longer striking against the submarine. Is it your fault when you lose contact? Perhaps—if you've been careless in operating the sonar gear. But more than likely, it is no fault of yours when you lose contact with the submarine at close ranges. Look at figure 4–13. Notice how a submarine can be shallow and pass from a position of contact at long range into a SKIP DISTANCE where an echo cannot be obtained. When the ship is in shallow water and the ocean floor is smooth, the sound beam will bend down from the surface to the bottom, then back up to the surface, and down to the bottom again.

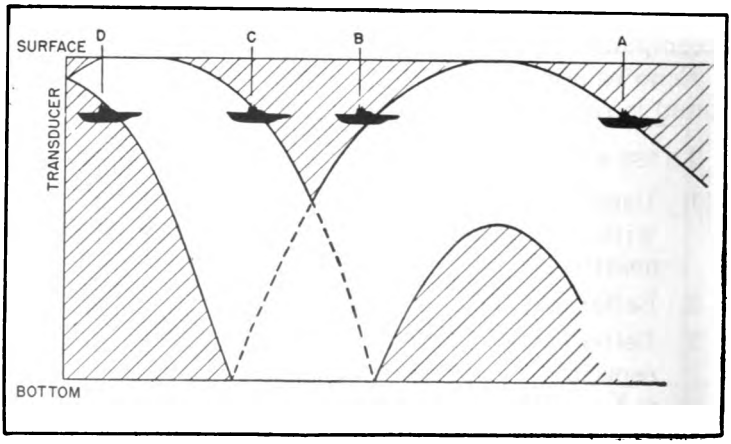

Figure 4–13.—In shallow water.

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When the sound beam acts in this manner, there are spaces empty of sound into which a submarine can pass and be undetected. These spaces are shown in figure 4–13. They are called SKIP DISTANCES.

Contact is regained when the submarine enters the beam again. Here is a case of making contact at long range (point A), losing it (point B), and regaining it at short range (point C). However, without the reflection of the beam, the maximum range would have been the short range at which the contact was regained (point C).

The reason for the loss of contact at short range is shown at point D, where the submarine passes beneath the beam. The distance at which contact will be lost at short range depends on the depth of the submarine. Here's a rough rule for this:

The range in yards at loss of contact is roughly equal to the depth of the submarine in feet. A contact lost at 300 yards would thus be presumed to be about 300 feet deep.

Once the behavior of sound in sea water is known, it is possible to PREDICT sound conditions in the sea. An experienced person can judge from the temperature gradient of the water what maximum range to expect. It is not expected that a Sonarman 3 or 2 will know how to predict sound conditions, but he should understand why results are poor one day and good another. A Sonarman 3 or 2 should know what is meant by skip distance and the reasons why sound does not travel in a perfectly straight line. He also should be able to distinguish between poor equipment adjustment and poor sound conditions.

SOME MORE ABOUT REVERBERATION

As noted previously, the outgoing sound wave traveling through water meets many hazards. Each hazard produces a small echo, which may return to the receiver. The combined echoes from all these obstructions are the reverberations.

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When the sound beam travels just under the water surface, reverberation intensity is greater than when the beam is directed away from the surface. The best reason for this is that the acoustic irregularities are greater near the surface.

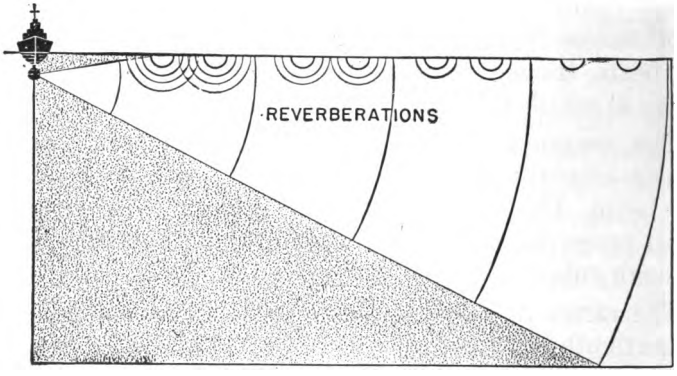

Figure 4–14.—Surface reverberations.

When the sound beam moves just under the water surface, that part of the wave passing through the irregularities tends to be reflected by them. This is illustrated in figure 4–14.

DOPPLER

When actually attacking a submarine, one of the most important pieces of information the Sonarman can give the conning officer is an accurate report of DOPPLER. As the submarine changes its course and speed to escape depth charges, nothing will give away its escape tactics as quickly as doppler.

You've heard doppler many times, but probably didn't know that it was called doppler. For instance, when you were stopped at a railroad crossing and listened to the whistle of the express as it approached, you will remember that the note of the whistle was HIGH as the train came

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near. As the train passed, the note or pitch of the whistle seemed to drop. And as the express went off into the distance, the pitch of the whistle was LOW. That change in pitch was DOPPLER.

As the train approached, sound waves generated by the whistle were compressed and pushed ahead as they came near. These waves were heard as a high pitch because they were compressed. The shorter the distance between waves, the higher the pitch. When the train went on, sound waves from the whistle were drawn out. These waves were heard as a low pitch. See figure 4–15 for an illustration of this.

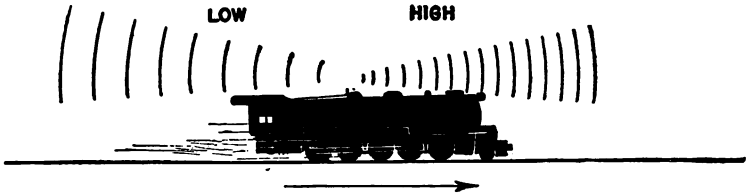

Figure 4–15.—Doppler.

Doppler works both ways. If you had been on that train instead of waiting at the crossing, and listened to the horn of the stopped car as you passed by, the pitch of the horn would be HIGH as you came toward it and LOW as you went away.

You probably are beginning to wonder what doppler has to do with sound in the sea or with submarines. Sonarmen deal with three sounds. One is the sound actually sent into the water. The second is the sound of reverberations that echo back from all the particles in the water—the seaweed, fish, and so forth. And then there is the most important sound of all—the sound of the echo from the submarine.

Forget about one of these sounds right now. That one is the sound sent into the water. Strangely enough, the actual PING is seldom heard. All but a few sonar equip-

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ments are designed so that the signal does not come out of the loudspeaker. This means there actually are only two sounds to deal with in doppler.

Reverberations are echoes from all the small particles in the water. Consider just one of these particles for a moment. A sound wave hits the particle and bounces back just as a ball would bounce back if thrown against a wall. If the particle is stationary, it will not change the pitch of the sound. The sound will return from the particle with the same pitch that it had when it went out.

Suppose you are on a DE and are stopped in the water. You send out a note of 20 kilocycles and the particles all send back a sound of the same pitch, that is, 20 kilocycles (20 kc=20,000 cycles per second).

Now suppose the ship gets underway and a ping is sent out dead ahead. It is just as if the ship were the oncoming train and the particles were sitting in the car listening to the approaching sound. Remember that as the train came forward, the pitch of the whistle sounded higher to the occupants of the car. In the same way, the particles "hear" a higher note and echo back a higher note. So, you, in the ship, will hear a higher note from the reverberations than the one sent out.

If the audio cursor is moved to dead astern, a lower note than the one sent out will be heard. Train the cursor on the beam, and the particles will echo back the SAME note sent out BECAUSE THE SHIP IS NEITHER GOING TOWARD THE PARTICLES NOR AWAY FROM THEM.

Look at figure 4–16 to see what happens when the ship is moving. Reverberations are highest when you train ahead and lowest when you train astern.

Consider the echo from the submarine. When the submarine is neither going toward nor away from the sound beam, it must be either stopped or crossing the sound beam at a right angle. If it is in this position, it reflects the same sound as the particles in the water. And the submarine echo is exactly the same pitch as the reverberations from these particles.

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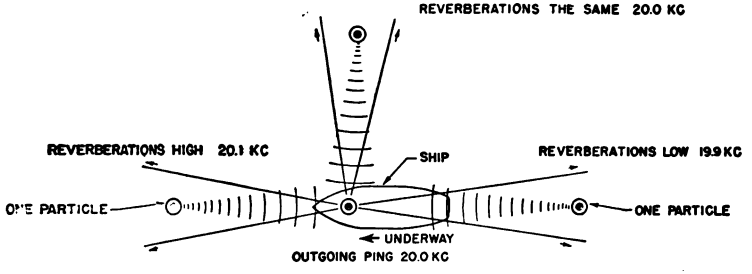

Figure 4–16.—Pitch is high ahead, low astern.

Whenever the pitch of the submarine echo and the pitch of the reverberations is the same, you know that the submarine is either stopped or that you are echoing off its beam. The submarine is neither coming toward nor away from the sound beam.

Figure 4–17 illustrates this. There is no difference in pitch between the echo from the submarine and the echo from the reverberation. Report NO DOPPLER.

Now suppose that the submarine is coming toward the sound beam. It's as though the submarine were the train coming toward the car which was blowing its horn at the crossing. The horn sounded higher as the train approached the car, and the sound beam sounds higher to the submarine as it approaches the ship. So the submarine hears

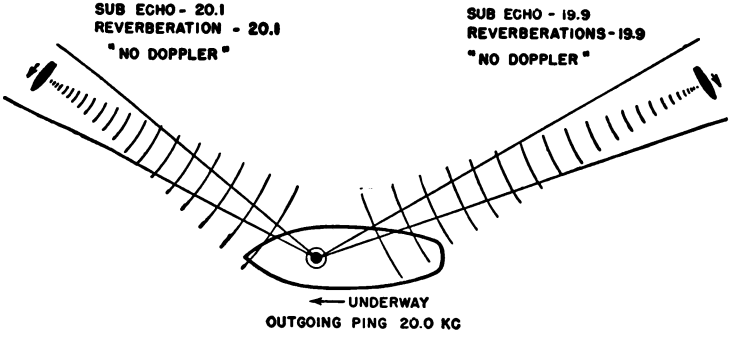

Figure 4–17.—You will hear no doppler.

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and reflects back a HIGHER echo than the particles in the water which are not moving. When the echo from the oncoming submarine is higher than the echoes from the reverberations, report DOPPLER HIGH.

When you report DOPPLER HIGH, you are telling the conning officer that the submarine is heading toward the ship. This form of doppler is illustrated in figure 4–18.

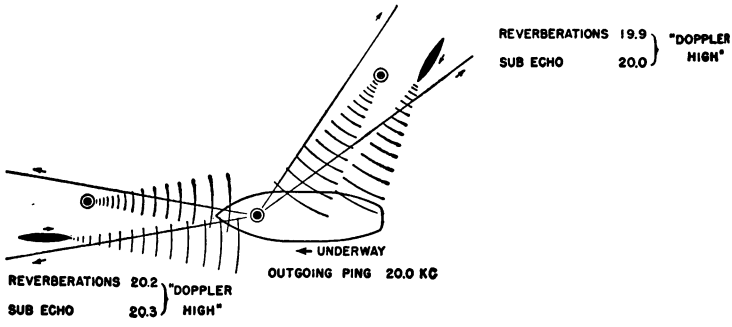

Figure 4–18.—Compare the echo and the reverberations.

The opposite form of doppler will occur when the submarine is heading away from the ship. In this case, the echo from the submarine will be lower than the pitch of the reverberations.

Report it as DOPPLER LOW so that the conning officer will know the submarine is going away from the ship. This is illustrated in figure 4–19.

If you like definitions, you can say that doppler is the difference in pitch between the reverberations and the submarine echo. When the echo is higher than the reverberations, you will sing out, "Doppler high!" If it's the same as the reverberations, report, "No doppler." If the echo is lower than the reverberations, say "Doppler low."

When you become a really skilled operator, you will be able to give the degree of doppler, that is, how high or how low it is. For instance, a submarine coming directly toward the ship at 6 knots would return a higher echo than

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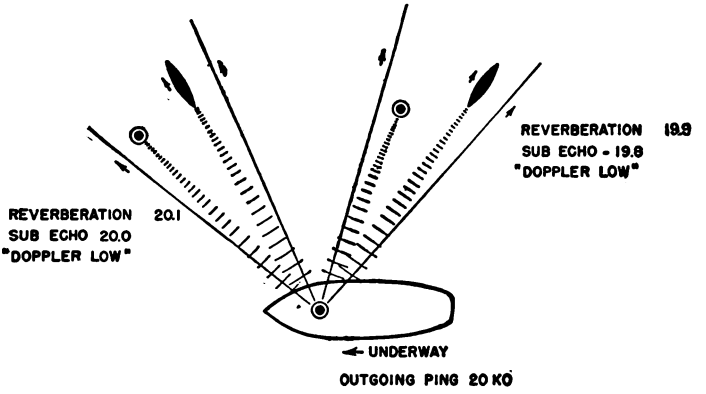

Figure 4–19.—You will hear DOPPLER LOW.

a submarine coming directly toward the ship at 2 knots. Also, a submarine coming directly toward the ship at 6 knots will return a higher echo than a 6-knot submarine that is heading only slightly toward the ship.

Two things count: how much speed the submarine is making, plus how much it is heading toward or away from the ship. The combination of these two is spoken of as the component of the submarine's speed toward or away from the ship. If the submarine's component is more than 6 knots, report DOPPLER HIGH (or LOW), MARKED. When it is 3 to 6 knots, inclusive, report DOPPLER HIGH (or LOW), MODERATE. If it's less than 3 knots, then call it DOPPLER HIGH (or LOW), SLIGHT. See figure 3–20.

You can see now how very important it is to give an accurate report of doppler to the conning officer. It tells conn whether the submarine is coming toward or going away from the ship and gives the component of the submarine's motion.

Doppler is also important to YOU, especially when making first contact and during the attack. Doppler enables you to tell the difference between a wake echo and a submarine echo. A wake echo is from a stationary object and can never have doppler. But anything that

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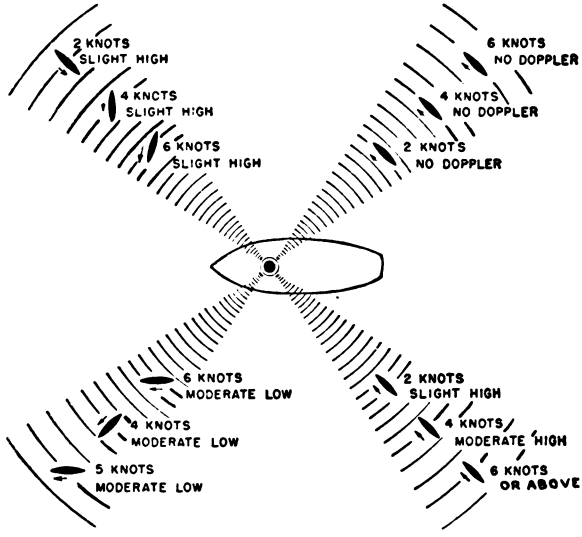

Figure 4–20.—Doppler gives component, toward or away.

does have doppler is moving in the water, and if it is not a surface ship it must be either a submarine or a large fish. Figure 4–21 gives an idea of the value of doppler.

The submarine's wake has no doppler but the submarine DOES have doppler. If you couldn't hear doppler, the echo from the wake would sound so much like the

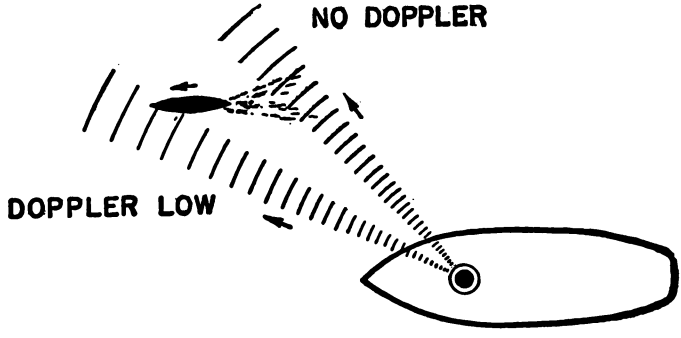

Figure 4–21.—You must hear the doppler.

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echo from the submarine that you couldn't tell them apart. TO BE AN EFFICIENT OPERATOR, YOU MUST BE ABLE TO HEAR AND REPORT DOPPLER ACCURATELY.

HOW TO RECOGNIZE ECHOES

Sonarmen learn to recognize one echo from another by listening to recordings of reverberations and echoes or by practicing with the sonar gear aboard ship. The following remarks will serve as helpful hints but they cannot take the place of actual practice.

There are two types of echoes, those with doppler and those without doppler. If an echo has doppler, you can assume that it is a submarine or a large fish or mammal, such as a whale.

If the echo has no doppler, it is either from the beam of a submarine, from a stopped submarine, from the submarine's wake, or it is not from a submarine. If an echo without doppler is from the beam of a submarine it will be a sharp clear echo because the side of a submarine presents a large reflecting surface.

Sharp loud echoes, without doppler, will be received from any large solid surface. The larger the area of the target, the greater the strength of the echo.

A weak mushy echo, without doppler, will be heard from such things as riptides, kelp beds, schools of small fish, and wakes that are breaking up. The weak mushy sound is caused by the numerous small reflections that combine in random fashion to form an irregular echo wave.

Oftentimes, you will receive the worst type of echoes from the stern of a submarine. The target area is small and is broken into multiple surfaces by the screws, the wake, and so on, so that there is a combination of reduced power and interference. Don't dismiss weak, poor-sounding echoes as nonsubmarine. Experienced Sonarmen will tell you that a contact from dead astern of the target is the hardest for an operator to identify.

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The strength of the echo will depend on the POWER of the incoming wave. And this depends on the sound output of the transducer, the size, position and movement of the target, and the conditions of sound transmission in the sea.

You'll probably hear a lot of miscellaneous sounds while echo-ranging. A rock near the surface will produce good echoes, but there will be no doppler. A whale may have echo characteristics closely resembling those of a submarine. Echoes may also be heard from blackfish or other large fish but they are usually too narrow in bearing to be easily distinguishable. A school of herring or other small fish frightened by a shark will sometimes crowd together into a good target mass.

Occasionally, you may hear strange chuckling and whistling sounds in an area where there are porpoises or dolphins. If the water is shallow and the bottom is hard, rocky, or covered with coral heads, sound waves will be reflected strongly. Often these reflections will return as loud and clear as echoes from a target but they will have no doppler.

From time to time, you may pick up strange sounds which must be identified. Submarine hydroplanes and rudders will sometimes give off a noticeable whistling sound. Submarine pumps and other machinery can be heard rattling or thumping if the machines have not been silenced. ALSO YOU CAN HEAR A TORPEDO.

HYDROPHONE EFFECT

Sound is generated whenever a disturbance is created in water. When this disturbance is random, the sound generated does not have characteristic quality or tone and is known as NOISE. A typical example of this is the noise that a ship's propellers make when the blade tips are moving rapidly through the water. This noise is known as HYDROPHONE EFFECT (HE).

Under usually good water conditions, the ventilating fan in a submarine has been known to create sufficient

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noise in water to be detected a few hundred feet. In this case, the noise was conducted from the fan to the water by the submarine's hull.

Some noises can be identified by certain characteristic rhythms. The propeller noises of a ship can be distinguished from the background of water noises. The propeller noise will have rhythm or beat whereas the background noise will be irregular.

Torpedo noise is distinct from all others. When a torpedo is fired, the first indication is a "whoosh" of air. This is quickly followed by a sound like a propeller noise and the appearance of a bright wedge on the cathode-ray tube. The rhythm is too rapid for the beats to be counted as you can count those of a ship's propeller, and it swiftly increases in speed until it becomes a flutter or tremolo.

PILLENWERFER

Submarines are capable of ejecting an artificial bubble screen target, sometimes called PILLENWERFER. Pillenwerfer is also known as FTS (false target screen), bubble screen, or pills. These bubble screens reflect an echo similar to a submarine, but show no motion or doppler.

Some pills are equipped to give noises similar to propeller noises. Sometimes submarines will release oil or debris at the same time they release the pillenwerfer. They draw this red herring across your trail hoping you will think you have put the sub out of action and will leave the scene.

Here are a few notes that should aid in recognizing pillenwerfer.

On release, the echo from the pillenwerfer is better than that from the submarine, and may mask the latter for a couple of minutes. You should become suspicious when there is a sudden change in doppler from "high" or "low" to "no doppler." Ordinarily this change in doppler would indicate a change of target aspect from bow or

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stern to beam-on, but when the target aspect changes, the submarine will show motion by bearing change. THE BUBBLE SCREEN WILL NOT SHOW MOTION AND EVENTUALLY WILL FADE AWAY.

The submarine will generally give a fainter echo than the bubble screen, but it will probably have doppler.

REPORT EVERYTHING YOU HEAR

One of the Sonarman's most important tasks is to pick out the echoes from other noise that tends to mask them. Sonarmen will hear many kinds of echoes. Rocks, shoals,

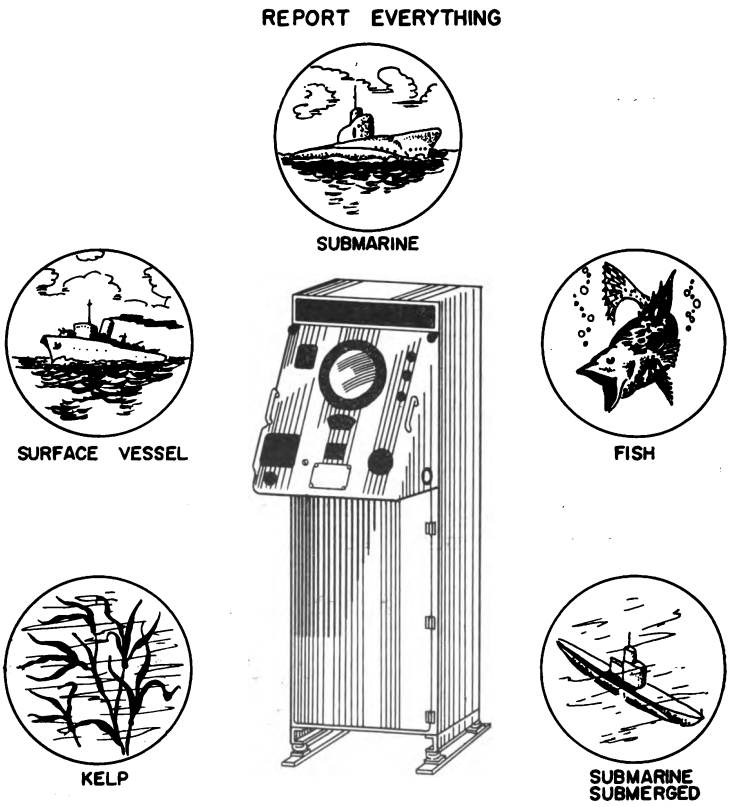

Figure 4–22.—Report each echo.

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buoys, mines, surface craft, whales, schools of fish, wakes of surface craft and submarines, as well as the subs themselves, can reflect sound.

Report everything heard regardless of whether you can identify the echo or not. The reason for this rule is plainly shown in figure 4–22. The life of a shipmate is worth more than the few depth charges expended against a false target. Sonarmen are the only protection a ship has against a submerged submarine.

THE EAR AS A SOUND DETECTOR

The ear is a good sound detector. It can detect a wide range of frequencies but does not respond equally well to all of them. Figure 4–23 is an illustration of the smallest amount of power which is just audible to the average ear at different frequencies. It is evident from this chart that the ear is most sensitive to frequencies in the range from about 1000 to 2000 cycles. The average person finds an 800-cycle note a rather pleasant one to listen to for long periods of time. In underwater ultrasonic echo-ranging equipment, the echo frequency is commonly converted to an 800-cycle note.

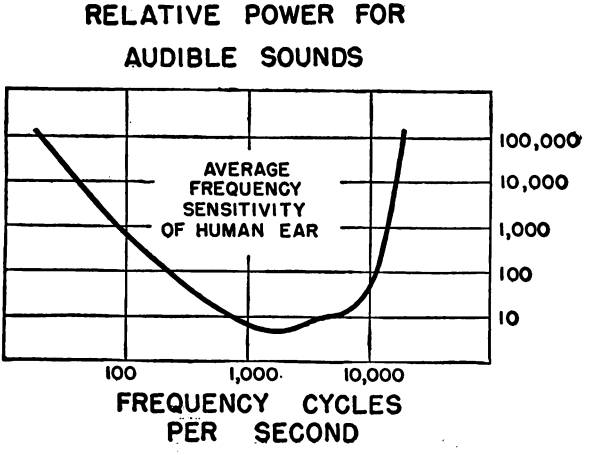

Figure 4–23.—Your ears hear sonics.

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Never turn up the volume on sonar equipment so that echo sounds are louder than necessary. One of the reasons for this is that the ear is not a sensitive detector of relative changes in sound INTENSITY. There must be an increase or decrease of about one-fourth of the total power before the ear will notice any difference.

An intensely loud sound slightly paralyzes the ear and reduces ability to hear low intensity sounds which follow immediately. This effect is similar to one you have probably experienced with light. If you look into a very strong light your eyes are momentarily blinded.

The ear is a sensitive detector of change in pitch or tone. The average person can tell when sounds differ a few cycles in pitch even though they cannot tell the frequency of the sounds or their intensity. This faculty, which is known as PITCH DISCRIMINATION, is a great help in picking out from a background of reverberations a submarine echo of slightly different pitch, that is, one which has doppler.

Here's a summary of your ear's characteristics:

1. Your ear does not readily detect small relative changes in sound intensity. It is not sensitive to high and low frequencies.
2. Your ear is sensitive to the 800-cycle note for which sonar equipment is designed. Your ear will be temporarily paralyzed by very loud signals or by nearby gunfire and you may not hear the following weaker signals.
3. Your ear has the property of pitch discrimination which will aid you in picking out an echo from the background of noise and reverberation.

Heavy gunfire often causes permanent deafness or other injury to your ears. USE EAR PROTECTORS OR COTTON when near gunfire, and take every precaution possible to protect your hearing. As a Sonarman, you are vital to the successful fighting of your ship. Your ability to operate sonar gear depends on your hearing.

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In a later chapter, you will read about the general constructional features of sonar transducers. This section will be confined to a brief discussion of the sound characteristics of searchlight-type transducers.

The dimensions, in wavelengths, of the radiating area of the sound source will determine whether or not the sound waves produced are to travel along a definite path or to travel in all directions from the source. When the diameter of the circular source is less than one-quarter of the wavelength, the sound from the source will spread in all directions.

Sonic frequencies have rather long wavelengths. Sound of 500-cycle frequency has a wavelength of about 10 feet in water. This means that a sound source for directional transmission at this frequency would have to be at least 4 feet in diameter. Obviously, this size is too large to be practical.

A frequency of 24 kilocycles per second would have a wavelength of 2.4 inches in water. A sound source for directional transmission at this frequency would have to be at least 1 inch in diameter. The larger the diameter in wavelengths, the narrower (beamlike) course the sound follows. Thus it is seen that a 24-kilocycle per second frequency can be easily beamed from sources of a practical diameter.

If a transducer could be made that would give a thin sharp beam in only one direction, it would be highly desirable. You would have to consider only the sound conditions, which cannot be controlled, to know what maximum ranges to expect—and the bearings would be accurate. A sonar transducer, however, does not produce the perfect beam desired. It sends out some sound in all directions within a 180° arc centered around the transducer face, the greatest intensity being within an arc of a few degrees. Figure 4–24 is an illustration of the directional characteristics of two sonar transducers.

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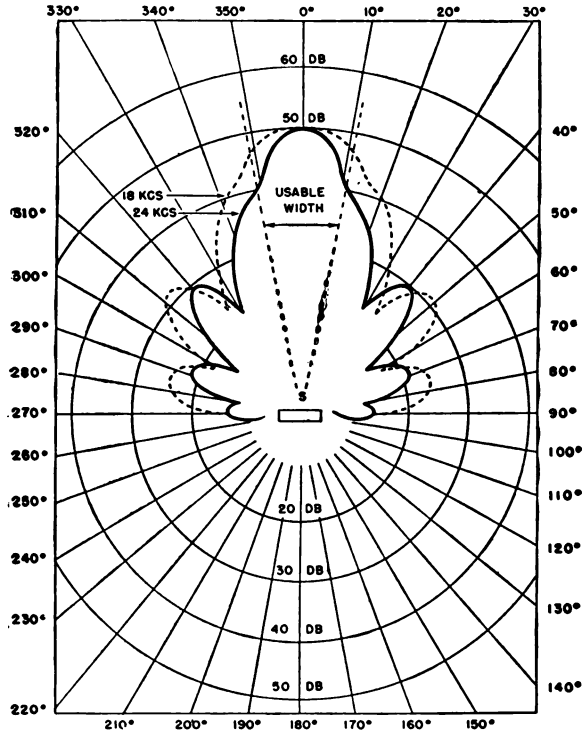

Figure 4–24.—The higher the frequency, the narrower the beam.

In figure 4–24 the dotted line represents the beam of an 18,000-cycle transducer, and the solid line represents the beam of a 24,000-cycle transducer. The diameter of these transducers is roughly eight times the wavelength.

The relative power of the beam in figure 4–24 at any point is represented by the distance out to that point along one of the lines that radiates from the center. The dotted lines from the center, drawn in over the pattern, represent that part of the 24-kilocycle beam that has enough power to be useful. It is this part of the beam that is used to get echoes. The "ears" and the remainder of the pattern are wasted power as far as echo ranging is concerned.

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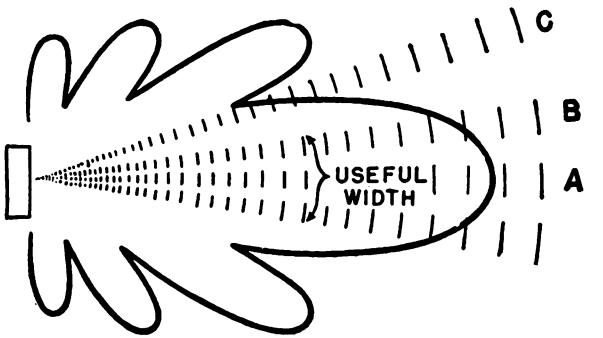
The beam pattern in figure 4–25 shows the action of the transducer with an INCOMING sound wave.

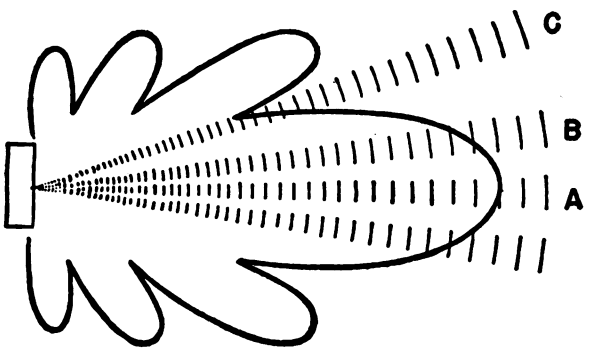
A weak signal, coming in along the beam axis as *A* does, will be easily heard. A signal coming in as *B* is, will have to be stronger to be heard, while a very strong signal may not be heard at all if it arrives in the fashion of *C*.

Figure 4–26 shows this same beam in the act of sending out sound waves. A very strong signal will travel out



TRANSDUCER AS RECEIVER

Figure 4–25.—A listening beam pattern.



TRANSDUCER AS TRANSMITTER

Figure 4–26.—The edges are weak.

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along the axis as indicated by *A*. A signal moving out in the direction of *B* will be weak, while a signal moving out like *C* will be very weak.

The lobes or ears of the pattern are not of any great importance in echo ranging, except that they indicate wasted energy. However, when sonar equipment is used for LISTENING or COMMUNICATIONS, the big ear can be a cause of dangerous confusion. This point is illustrated in figure 4–27.

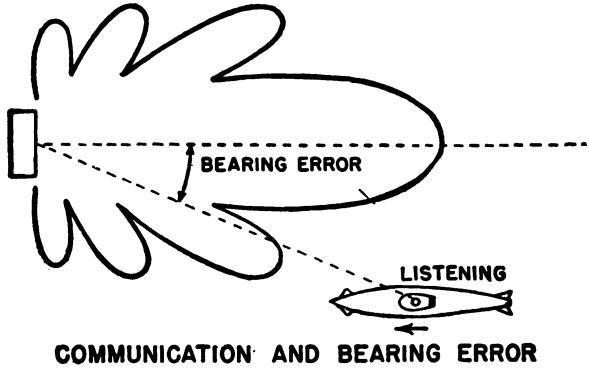

Figure 4–27.—Stay on the axis of the beam.

Communicating by sound is quite different from echo ranging. In a direct transmission, a great deal of the sound energy reaches the receiving transducer. In echo ranging, most of the transmitted energy is lost passing the target, and the returned echo is extremely weak. Because of the high level of direct transmission, communication signals can be picked up well off the axis of the beam. The likeliest place for this to happen is on the crest of the main ear as illustrated in figure 4–27.

A signal received in one of the side ears, as YOU hear it, will be of reduced intensity as though the submarine is some distance away when really it may be close aboard. Also, the submarine's bearing will be indicated to be the same as the axis of the beam, not of this ear, which may

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be a direction 40° to 65° away from where the submarine is actually bearing. It is understandable that the combination of this bearing error and the possibly misjudged distance can be dangerous. For instance, a surface ship may be directing a submarine to surface during training exercises, thinking it is safe to do so, when actually the sub may surface in a location where a collision will be imminent.

Therefore, when using echo-ranging equipment for communicating, move the transducer 60° to 70° on either side of the supposed bearing of the incoming signal to make sure the sound received is NOT ON A SECONDARY LOBE.

When using the sonar equipment for listening, and when the propeller noises are very loud, this same phenomena may be encountered. It's a good idea to search periodically on each side of the listening bearing to avoid bearing on the target with a secondary lobe.

The beam can be narrowed by increasing the frequency, since this increases the ratio of diameter to wavelength. Generally, however, sonar transducers used for echo ranging are designed for one particular frequency and work best at that frequency.

There is a way to effectively narrow or widen the beam pattern. This is by changing the RECEIVER GAIN and is illustrated in figure 4–28A and B. You know that the transducer will generate a signal of given strength, as indicated by the beam pattern. If you raise the sensitivity of the receiver, you can ACCEPT a weak signal coming in over a fairly large angle. This is pictured in figure 4–28A.

Or, you can LIMIT the signals received, as illustrated in 4–28B. So, by varying the receiver gain, you can build limiting walls around the axis of the beam pattern. As you vary the gain setting, you will receive signals over a wide angle or a narrow angle. This point is very important in the last stages of an attack when you do not want to swing the transducer over a wider angle than

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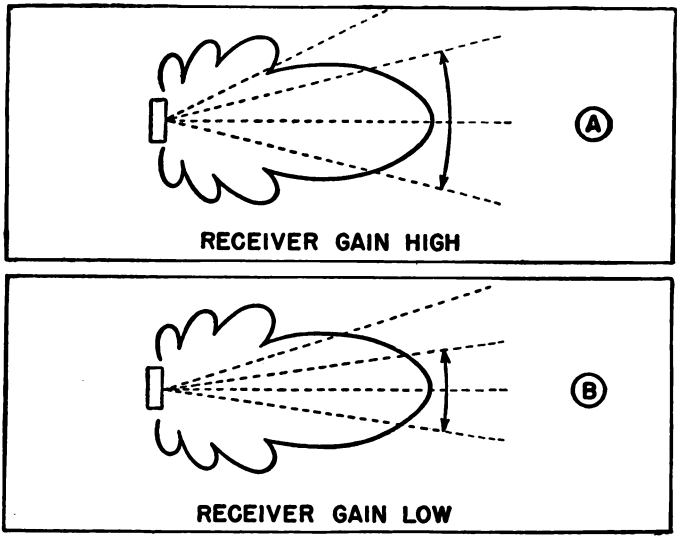

Figure 4–28.—Keep the gain low during an attack.

necessary and when you will be trying to obtain the most accurate bearing possible.

This gain control leads to an important operating rule. Keep the gain low during an attack. With the gain low, signals coming in along the path of best reception will be of just sufficient strength to produce a good signal from the speaker. Signals from other directions will not be amplified enough to be heard. Keep the gain high during search so that you can hear weak signals from the edges of the beam.

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QUIZ

1. If you are steaming at 15 knots and make a sonar contact on your starboard beam, what will be the doppler in the following cases?

TARGET ANGLE	SUB'S SPEED
(a) 000°	6 knots
(b) 270°	2 knots
(c) 180°	0 knots
(d) 180°	4 knots

2. Give the doppler for the following cases:

RELATIVE BEARING	TARGET ANGLE	SUB'S SPEED
(a) 010°	270°	6 knots
(b) 250°	180°	4 knots
(c) 183°	000°	2 knots
(d) 342°	090°	6 knots

3. How would the doppler change if a submarine did the following things:
   (a) Turned from a target angle of 090° to 180° while making 4 knots?
   (b) Changed speed from 2 to 6 knots, while the target angle remained 000°?
   (c) Turned from target angle of 090° to 000° while making 6 knots?
   (d) Changed speed from 6 knots to 0 knots, while the target angle remained 270°?

4. Which of the following will give the lowest doppler:
   (a) Target angle 180°, speed 2 knots;
   or, target angle 200°, speed 6 knots?
   (b) Target angle 120°, speed 4 knots;
   or, target angle 210°, speed 4 knots?
   (c) Target angle 135°, speed 4 knots;
   or, target angle 095°, speed 6 knots?
   (d) Target angle 140°, speed 6 knots;
   or, target angle 220°, speed 4 knots?

5. With temperature as shown, would the sound beam bend up or down in the following cases?

SURFACE	100 FEET	200 FEET
(a) 70°	75°	80°
(b) 80°	75°	70°
(c) 70°	70°	70°
(d) 80°	80°	80°

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6. Why is it desirable to reduce gain when attacking a submarine?

7. Name three factors influencing the speed of sound through water.

8. What produces scattering?

9. Give the wavelength of the following examples:

(a)	(b)	(c)	(d)
5,000 / 20,000	4900 / 14,000	5300 / 12,000	4800 / 8000

10. What is hydrophone effect?

11. What is the effect of increasing temperatures on the speed of sound? Increasing pressure?

12. What is meant by "skip distance?"

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CHAPTER 5

THE BATHYTHERMOGRAPH

RECORDING WATER TEMPERATURES

Efficient use of sonar demands exact knowledge of water temperatures taken in the area of A/S operations at the time operations are underway. In the last chapter you learned that the path of sound is controlled by a number of variables, most important of which is water temperature. It is possible to measure this variable with a bathythermograph (BT), and thus predict the effective range of sonar equipment. The bathythermograph, a sensitive thermometer, records temperatures at various depths. It is lowered by cable from surface ships and is hull-mounted on submarines.

This chapter discusses three surface ship BT's of the B-series: OC–1B/S, –2B/S, and –3B/S. Depth range of each BT is indicated in the table below.

TYPE	DEPTH RANGE (Feet)
OC–1B/S	0–200
OC–2B/S	0–450
OC–3B/S	0–900

The B-series is paralleled by three BT's of the C-series, from OC–1C/S through –3C/S. BT's of the two series have identical operating characteristics, but parts are not interchangeable. All BT's have this in common: They

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are delicate instruments, easily damaged or lost during observation. They require great care in storage and when handling during lowering and retrieving.

PRESSURE AND THERMAL ASSEMBLIES

The two principal inside assembly parts of the BT are the pressure element assembly and the thermal assembly. These are supported and protected by the body tube, the nosepiece, and the tailpiece. If you will look at figure 5–1 you can see what a BT looks like and where these parts are located.

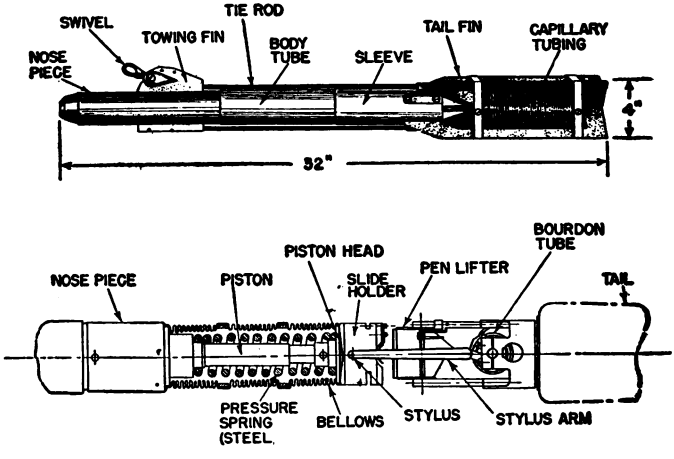

Figure 5–1.—The BT and its parts.

The pressure element is located in the body tube and consists of a piston device with an accurately wound steel spring. An envelope made up of three metallic bellows soldered together surrounds the spring and keeps the water pressure off the spring and off the spring side of the pistonhead. In one type of BT one end of the bellows assembly is soldered to the solid nosepiece, while in another type this end is soldered to the mounting base. The other end—the movable end—is soldered to the spring

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side of the pistonhead in both types. Increasing water pressure will tend to collapse the bellows and compress the spring, causing the slide holder attached to the pistonhead to move forward, that is, toward the nose of the mounting case.

The THERMAL ASSEMBLY is the temperature-measuring element. It is made up of about 45 feet of copper capillary tubing connected to one end of a Bourdon tube assembly, and filled with liquid xylene. The temperature reading represents the average temperature of the capillary tube assembly, the latter being wound in staggered fashion on a six-sided frame that extends beyond the body of the BT. This ensures a flow of water around the capillary tubing. Breather holes in the body tube allow water to run freely in or out to keep the internal pressure equalized with the outside pressure. The Bourdon tube element has a bimetallic strip so that any difference in temperature between the water within the BT surrounding the Bourdon tube and the water flowing past the capillary tubing is offset by the action of the bimetallic compensator.

The temperature range of the BT is 28° to 90° F. Temperatures below 28° F. will not harm the temperature-measuring element, but temperatures above 105° F. may result in a permanent set of the Bourdon tube.

The BODY TUBE serves as the main support and protection case for the pressure element and thermal assembly. The movable brass sleeve covers the slide ports next to the slide holder. The sleeve may easily be moved forward when it is necessary to get at the slide and slide holder. When the BT is to be lowered, push back the sleeve until it touches the forward end of the tail fins. This will cover the slide ports and also release the pen lifter so that the stylus can write on the smoked glass slide inserted in the slide holder.

A large percentage of the BT's weight of about 25 pounds is concentrated in the NOSEPIECE. This makes the

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nose sink first during a BT lowering if the towing cable is payed out freely. The nosepiece is at the forward end of the BT and has an attached towing fin, swivel, and shackle where the towing cable may be attached easily.

The TAILPIECE ASSEMBLY consists of the fin pieces strengthened with two tie strips. This assembly protects the capillary tubing and stabilizes the BT during the lowering, towing, and raising of the instrument.

On vessels moving at high speeds, earlier models of the deep bathythermograph often failed to dive to the depths for which they were set. Two types of DIVING ATTACHMENTS have been added to overcome this difficulty. One is a heavy bronze sleeve slipped over the nose of the instrument and secured by tightening two locking screws. This adds to the weight of the BT and increases diving speed. Also, own ship can move at higher speed and the BT will still reach full depth. The table below, based on paying out 1000 feet of cable, shows the maximum ship speeds that can be used with and without the nose sleeve. Note, for instance, that to get the BT down to 900 feet (type OC–3B/S) without the nose sleeve, own ship's maximum speed would have to be 3 knots. With the nose sleeve, the speed could be as great as 6 knots.

BT type	Depth (feet)	Maximum speed	
		Without nose sleeve	With nose sleeve
OC–1B/S.....OC–1C/S	200	15	22
OC–2B/S.....OC–2C/S	450	10	13
OC–3B/S.....OC–3C/S	900	3	6

The other device is a towing block attached well aft on the BT and used while lowering the instrument. This attachment causes the BT to dive at a steep angle because the towing point is well aft.

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AUTOMATIC STYLUS LIFTER

When retrieved by a fast ship, a BT will tow along the surface where stylus vibration tends to obscure the trace on the smoked slide. To prevent this, a device automatically lifts the stylus from the slide as the BT approaches within 80 to 50 feet of the surface. The automatic stylus lifter is found in OC–1 (B/S and C/S) and OC–2 (B/S and C/S), but not in OC–3 (B/S and C/S). Older BT's of the A-series were not equipped with stylus lifters.

WINCH

The winch is the gear that provides the power for hoisting and lowering the BT. It is usually located aft and outboard on the ship. The entire winch assembly weighs about 450 pounds and has 1200 feet of wire cable.

Parts of the winch are shown in figure 5–2. There is a drum on which the towing cable is wound. The counter gives the number of revolutions of the drum and therefore the amount of cable payed out. The motor furnishes the power for the hoisting operation. A junction box is

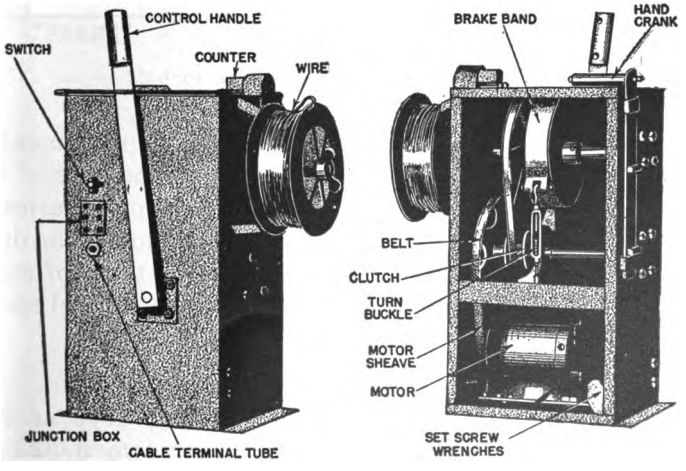

Figure 5–2.—The BT winch and its vital parts.

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provided on the side of the winch for connecting the motor to the ship's power supply. There is also a shafting and pulley system with brake and clutch.

The control lever for operating the brake and clutch mechanism is shown in figure 5–3. This lever may be set at NEUTRAL, pushed toward the drum to the HOIST or CLUTCH position, or pushed away from the drum to BRAKE. Note in figure 5–2 that there is a switch for turning the power supply on and off. The control lever should always be in the brake or neutral position whenever this switch is turned on or off. Do NOT turn the power supply on or off when the motor is under load and when the control lever is at the hoist position. It will damage the switch and probably burn out the contacts.

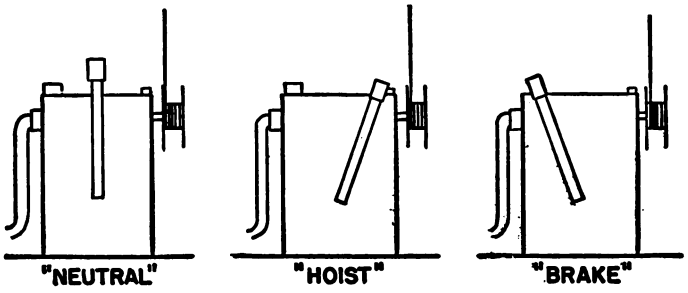

Figure 5–3.—Positions of the lever control.

There is another type of winch that differs somewhat in detail. The motor starter, located on the side of the stand, automatically protects the motor from overloads. The motor should NOT be turned off under load. The driving mechanism for this type of winch is a train of gears which reduces the motor shaft speed to proper reel speed.

CABLE

With each winch installation are 1200 feet of 7x7 strand stainless steel airplane cable, or two 3/32-inch preformed 7x7 strand stainless steel cables with 1/32-

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inch nylon coating. This expensive cable is normally tough. However, it cannot be spliced, and is weakened by kinking. You must take constant care to guard against kinking the cable. Before ordering replacement cable, check the winch (or hoist) instruction book for part number and Navy stock number.

One end of the cable should be secured to the winch drum and fixed in such a manner that it cannot pull loose even though all the cable is allowed to run off the drum. After the cable has been wound on the drum, the other end should be rove through the sheave and fastened to the swivel on the nose end of the BT. The swivel prevents the cable from twisting and kinking during normal operation.

In hot weather, when it may be necessary to detach the BT between lowerings, a screwdriver may be used to unfasten the BT, leaving the swivel attached to the cable.

Attaching Swivel to Cable

Here is the procedure for replacing a cable swivel (study swivel parts illustrated in fig. 5–4) :

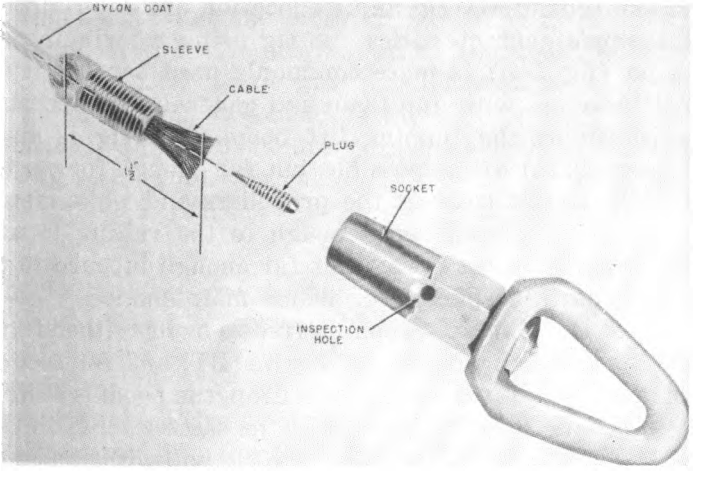

Figure 5–4.—Cable swivel installation.

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1. Cut the nylon coat back 1½ inches as shown in figure 5–4.
2. Slide the sleeve onto the cable.
3. Fan out the individual wires uniformly.
4. Insert the wire-center plug as near the center of the fanned wires as possible.
5. Drive the plug to a solid seat.
6. Compress the extended strands to permit attaching the socket portion of the fitting.
7. Screw the swivel socket to the sleeve and tighten securely.
8. If the twisted cable does not show across the inspection hole after carefully following the above instructions, it indicates that not enough cable has been allowed to project beyond the sleeve mouth. In succeeding assemblies, cut the nylon coat back somewhat more than 1½ inches until the twist shows satisfactorily.

BT RIGGING

The type of BT rig and its location are determined by the ship's characteristics. A rig using a swinging gate boom (fig. 5–5) is more commonly used because it does not interfere with gun train and general deck operations as much as the topping lift boom. The rig is always located as far aft as possible, but far enough forward for the BT to tow clear of the propellers and wake disturbance. It is placed near enough to the railing to avoid blocking the passageway, but far enough inboard to permit removal of panels for winch maintenance.

The swinging gate boom is free to swing either fore or aft for lowering or retrieving the BT, and for securing the rig. When in position for a drop, the boom is stiffened by fore-and-aft guys secured at the same level as the foot of the boom. In this position, the rig will withstand a pull of 1200 pounds on the cable aft, and a pull of at least 400

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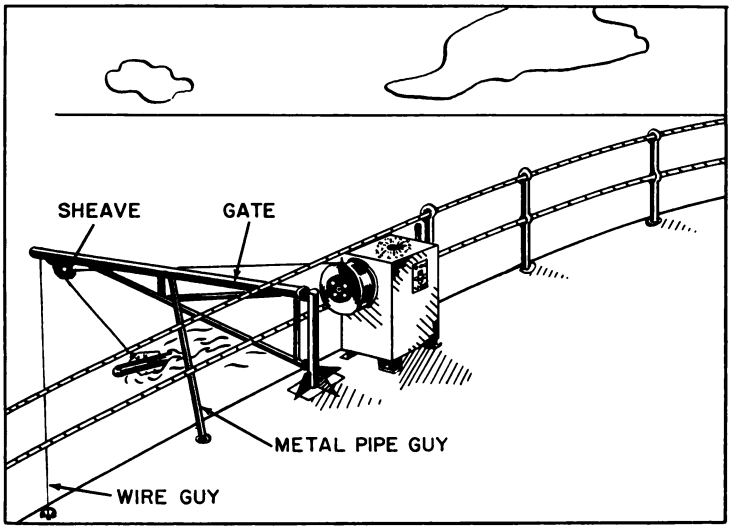

Figure 5–5.—Swinging gate boom.

pounds down. Extended, the boom keeps the BT clear of the propellers and the ship's side.

The cable leads horizontally from the hoist drum to the sheave at the end of the boom, and forms a 90° angle with the drum shaft when the sheave is hauled horizontally by the tow of the BT. The guys stabilize the boom, holding it at a constant 90° angle when the BT is streamed. It is very important that the boom be guyed.

Caution.—Do not use more than one sheave at the end of the boom to guide the cable.

BT SLIDES

The bathythermograph makes a continuous temperature-depth record in the form of a curve scratched on the smoked surface of a small glass slide. This slide is inserted in the BT slide holder before the BT is lowered into the water. Fifty smoked slides are packed in a box, four boxes per BT. Figure 5–6 shows the actual size of the slide and trace.

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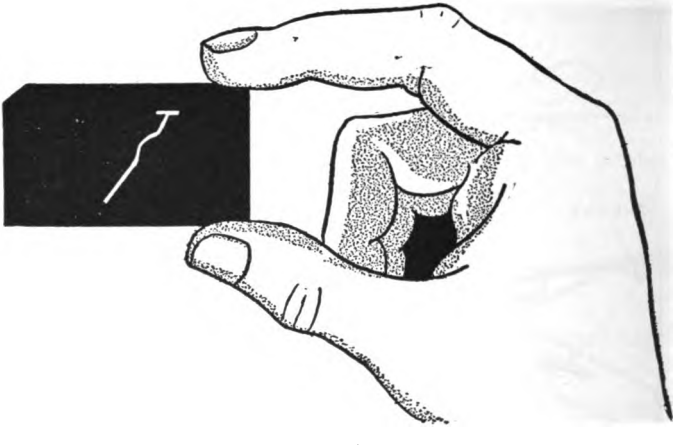

Figure 5–6.—The BT trace.

Inspect a few samples of the slides in a new box before using them. If the smoked surface of a new slide is in bad condition, or if the smoked surface shows spots after it has been lowered in the BT, test all slides in the box by holding each slide under a moderate stream of water. Reject any slide that shows spotting or flaking on the smoked surface.

If the supply of new slides on shipboard gives out, the rejected slides can be used. First, wipe them clean and smear one side with a very THIN FILM of grease. Then smoke the greased side by holding it over a match or a candle flame. Hold it by tweezers furnished with BT equipment.

In an emergency, use a slide that already has been used and lacquered. Dip this used slide in thinner, wipe it clean, grease it, and resmoke it. Use a new slide whenever possible because traces are preserved for study and research.

BT OPERATIONS

Before lowering the BT, first obtain permission from the officer of the deck. The ship should be on a straight

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course. If you have a properly operating motor-driven winch, the BT will be in the water 5 minutes, or less, during a lowering.

Loading

Load the BT with a slide. To carry out this operation, push the movable brass sleeve toward the nose so that the slide ports are exposed. The following procedure will be more convenient if the BT is lashed in its rack nose up. Hold the slide between the thumb and forefinger of the right hand with the smoked surface up or toward you. Make sure that the edge with the beveled corners is toward the left. Feed the slide from right to left into the top and bottom grooves of the slide holder with the beveled corners leading. Look at figure 5–7 for an illustration of this procedure.

Push the slide just hard enough for it to ride over the spring in the bottom groove. Then shove it firmly all the way in until the edge SEATS AGAINST THE STOP PIN of the

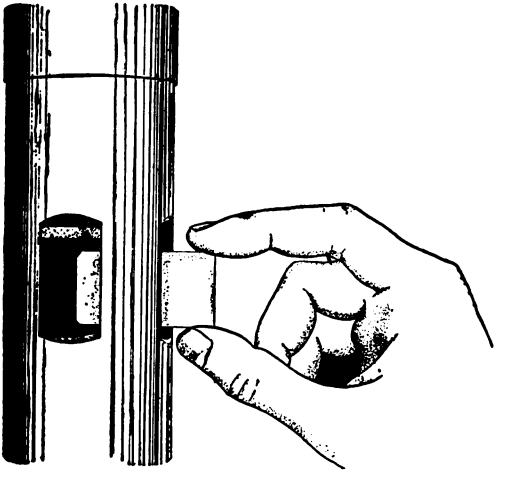

Figure 5–7.—Inserting the slide properly.

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slide holder. If this edge is not sent home against the stop pin, large errors will be made in temperature readings. Make sure that the upper edge of the slide is held EVENLY against the top of the holder by the pressure of the spring on the bottom edge of the slide. Inspect the slide and the holder to ensure that edges of the slide are clean and that the surface of the top groove is entirely clear and clean.

Before lowering the BT, try the swivel to see if it is working freely, and examine the hitch carefully for signs of weakness.

Lowering

Either just before or just after the bathythermograph is lowered, enter the time, speed, and surface temperature on the log sheet. The remaining items on the log sheet may be entered at any time within about 15 minutes of the lowering.

Determine the depth of the water where the BT is to be lowered, from either a fathometer or a chart.

When depth is known, compute the time in seconds, or number of revolutions of the drum, necessary to lower the BT to the desired depth. In figure 5–8 there is a graph that shows the approximate seconds of time during which the cable must pay out freely at different ship's speeds to reach a given depth.

It is much better, however, if data are taken on the number of REVOLUTIONS and actual depths obtained by the BT at several speeds. Plot a graph like the one in figure 5–9 for own rig after a number of lowerings.

The drum revolution counter is usually a more accurate means of estimating depth than is the time of sinking in seconds. Attempt to get full-scale depth whenever safe to do so.

Turn on the winch motor, pull down the brass sleeve on the BT (to place the stylus against the smoked surface of the slide), unlash the BT from its rack, and swing the

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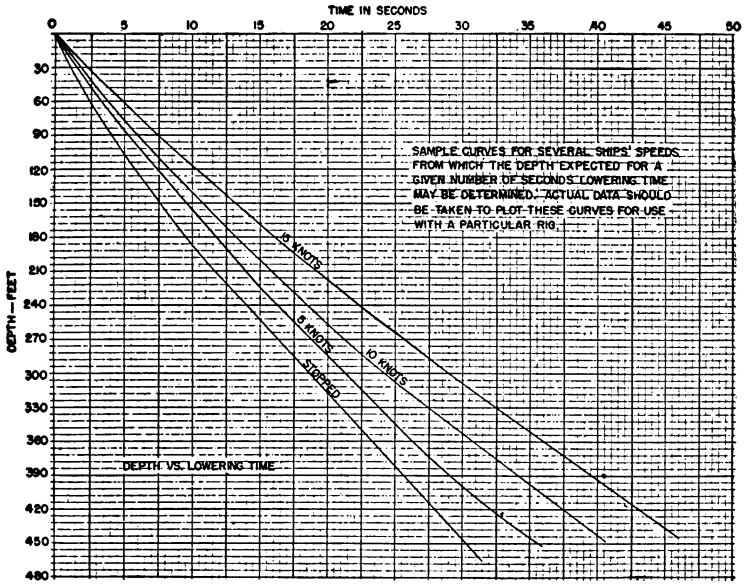

Figure 5–8.—Depth vs lowering time.

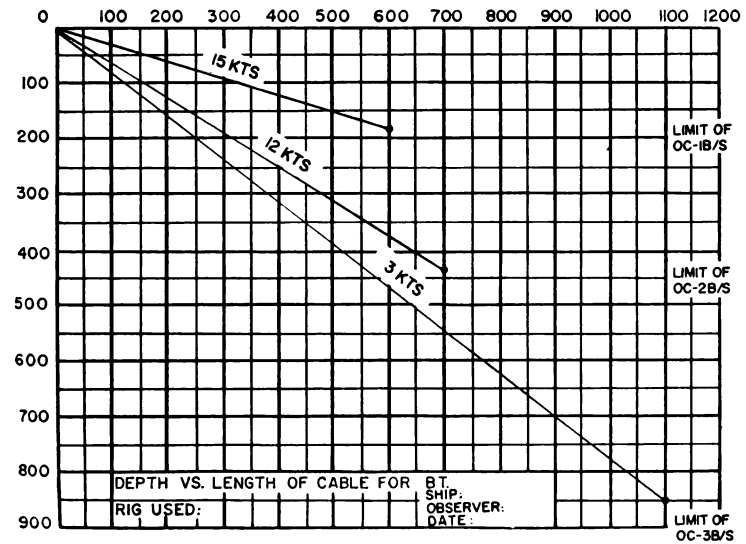

Figure 5–9.—Depth vs cable out.

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boom and BT outboard carefully until the BT is hanging clear of the water about 2 feet below the boom. Avoid jarring the BT since the stylus is now against the slide. Slack off the brake and lower the BT gently until it is towing just under the surface, without skipping, at a safe spot alongside, and forward of the propeller disturbance. Set the brake and tow the BT in this position for at least 30 seconds. This will allow the body of the BT to fill with water and the temperature of the BT to come to that of surface water.

While towing, do the following:

1. Set the revolution counter to zero .
2. Check the cable to see that it is leading properly to the towing block; check the adjustment of guys; and so on.
3. Be sure to remember how much cable you expect to pay out.

Lower and raise the BT carefully. At speeds above 15 knots, the BT will dive to maximum depth only when every part of the winch and rig is in adjustment and only when every detail of the lowering is carefully attended to. Bearings and shafts must be lubricated and must be free of corrosion.

The drum must turn freely when the hand lever is in the neutral position. The cable must have a fair lead directly from the winch drum to the sheave, without bending sharply over the flange of the drum, and it must run through the sheave with minimum friction.

Don't drag the brake or clutch. If this happens, the cable will not pay out freely. When the ship is underway, it is impossible to let the cable pay out too fast. Don't jam on the brake in stopping, but start applying it smoothly just before bringing the winch to a full stop. When the drum has been braked to a full stop, read the drum revolutions which show the amount of cable out.

When making a lowering from a ship NOT UNDERWAY, pay out the cable at less than normal speed. This can be

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done by engaging the clutch against the pull of the motor, or by turning off the motor switch and allowing the motor to drag against the pull of the cable. Remember, though, the switch must not be turned on or off while the motor has any load on it. When the ship is not underway, it is dangerous to apply the brake suddenly if the cable is paying out at full speed. When the ship is hove to and the cable is almost vertical, be especially careful to use your free hand and a stick as an "idler" on the outgoing cable. The cable will often go slack as the ship rolls and will kink if this is not done.

Hoisting

When hoisting, swing the winch lever smartly through NEUTRAL to HOIST. Operate the winch lever with the left hand and guide the cable back and forth onto the drum with the right hand until the BT is alongside. Wear a thick leather glove or use a wooden stick to guide the cable onto the drum. If you attempt to guide the cable with your bare hand, you risk injury.

Haul in at full speed until you see by the counter, or by a rapid change in the angle which the cable makes with the surface, that the BT is close astern but still a safe distance from own propeller. WATCH THE CABLE and be alert to slow down or stop if the cable coming in is fouled by seaweed. Remember to keep your eyes on the cable, only glancing at the counter from time to time.

When the BT is safely astern, or near the surface, slow the speed of the winch by slipping the clutch. This requires practice. Get the feel of the winch and learn how to bring the BT alongside safely and slowly past own propeller, KEEPING AN EVEN TENSION ON THE CABLE until the BT is directly under the boom. By gently increasing the power for a moment, the BT can be raised vertically out of the water until it is about 2 feet below the boom. Then set the brake quickly and firmly.

It takes an experienced man to retrieve the BT by the

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method described above. An alternate, and safer, method is to bring in the BT under power to the last 50 to 25 feet. From this point, bring the BT to within 2 feet of the sheave by a hand crank provided with every winch installation. Holding the BT 2 feet below the sheave allows sufficient slack to swing the boom in.

If the cable becomes too slack while hauling in the BT, it may kink. If the BT is brought in too fast, it will skip forward of the boom and swing too much, perhaps hitting the side or swinging over the boom. If the BT does skip or swing forward of the boom, it's advisable to shift at once to neutral and allow the BT to sink freely until it has passed well astern. Then try bringing it in again when it seems safe to do so. Take it easy with BT operations.

If the power fails when the BT is being raised, use the hand crank. Place the handle over the winch drum shaft with the handle lug inserted against one of the drum spokes. Tighten the wingnut to hold the handle in place. Put the control handle of the winch in the neutral position and raise the BT by turning the hand crank.

When the BT is hanging from the boom clear of the water, swing the boom inboard, slacking off on the cable as necessary. After the BT is safely aboard, lash it in its rack. Secure the rig and turn off the motor.

Next, remove the slide. Raise the brass sleeve and push a small screwdriver against the corner of the slide below the stop pin until the slide can be grasped with the forefinger and thumb of the right hand. After a preliminary examination of the slide, dip it in fresh water, label it, lacquer it, place it in the box, and close the box cover. Keep the cover closed until the slide is dry. If time permits, let the slide dry after it has been dipped in fresh water. Then label and lacquer it.

When hoisting operations have been completed, finish the BT log sheet entries, giving special attention to the following:

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1. The Greenwich mean time of lowering.
2. Actual speed at time of lowering.
3. Number of revolutions of wire out. The last two columns of the log sheet may be used for recording this information.
4. Appropriate notes on condition of weather.
5. Injury to the instrument or failure of the rig and how it happened.

BT LOG SHEET

The BT log sheet is a convenient form for recording the conditions that are present when each slide is made. A detailed study is being made of the upper layers of the ocean. The BT is the best tool so far developed to get the necessary information, and accurate BT records from all parts of the ocean are needed to solve some of the most vital problems of naval warfare. Therefore, always fill in the BT log sheet clearly and completely, and return it with the slides to The Hydrographer, Hydrographic Office, Navy Department, Washington 25, D.C.

It's a good idea to lower the BT at the time weather observations are made for entry in the ship's deck log. Duplicate efforts can often be avoided, and MUCH OF THE INFORMATION ON THE BT LOG SHEET CAN BE COPIED DIRECTLY FROM THE ENTRIES IN THE DECK LOG. HOWEVER, YOU ARE RESPONSIBLE FOR THE ACCURACY OF THE ENTRIES ON THE BT LOG SHEET. If weather conditions have changed since the last entry in the deck log, make a new observation and enter the actual conditions at the time the BT was lowered.

Figure 5–10 is an illustration of the BT log sheet. Start a new sheet on the first day of each month, and at the beginning of a cruise. Draw a heavy line across the sheet just under the last slide taken on a particular date. When the slides are forwarded, be sure to include the BT log sheet for these slides.

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Here's a description of the information that must be entered in the various columns of the log sheet.

ESSENTIAL ENTRIES

Column 1—SLIDE NUMBER: Slides are to be numbered and labeled consecutively between two ports.

Column 2—TIME: Enter Greenwich mean time (0000 to 2400) only. This is the time at which the BT enters the water.

Column 3—DATE: Enter 1 to 31 for the day of the month. The month and year should appear at the top of the sheet. Remember, the date changes after 2400 GMT. Do not confuse it with midnight, local time.

Column 4—LATITUDE: Enter in degrees and nearest minute the latitude of the spot where BT was lowered, followed by N for north latitude or S for south latitude, as 38°41′ N.

Column 5—LONGITUDE: Enter in degrees and nearest minute the longitude of the spot where BT was lowered, followed by E for east longitude or W for west longitude, as 58°32′ W.

Column 6—BT NUMBER: Enter the serial number stamped on the instrument used in obtaining each slide.

ENTRIES TO BE MADE AS CLOSE AS POSSIBLE TO TIME OF LOWERING

Column 7—DEPTH IN FATHOMS: This should be checked before each lowering to avoid hitting bottom. Indicate how depth was obtained by entering F for fathometer, L for hand lead, or CH for chart.

Column 8—SPEED IN KNOTS: The ship's speed while the BT is being lowered should be entered.

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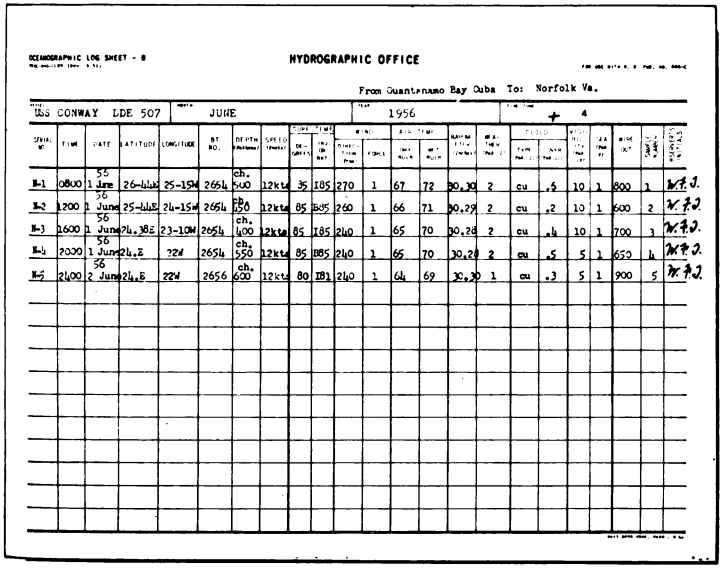

OCEANOGRAPHIC LOG SHEET - B

HYDROGRAPHIC OFFICE

From Guantanamo Bay Cuba To: Norfolk Va.

USS CONWAY LDE 507 JUNE 1956 4

SERIAL NO.	TIME	DATE	LATITUDE	LONGITUDE	BT NO.	DEPTH (Fathoms)	SPEED (Knots)	TIME OF CAST OFF	TIME IN WATER	WIND DIRECTION (From)	WIND FORCE	AIR TEMP WET BULB	AIR TEMP DRY BULB	BAROM. CORR. (Inches)	WEA. THER PAST	FIELD TYPE	FIELD NUMBER	WIRE OUT	WIRE IN	SAMPLE NO.	REMARKS
M-1	0800	1 June 56	26-44N	25-15W	2654	ch. 500	12kts	35	185	270	1	67	72	30.30	2	cu	.5	10	1	800	1	W.T.J.
M-2	1200	1 June 56	25-44S	24-15W	2654	ch. 650	12kts	85	185	260	1	66	71	30.29	2	cu	.2	10	1	600	2	W.T.J.
M-3	1600	1 June 56	24.3S	23-10W	2654	ch. 400	12kts	85	185	240	1	65	70	30.28	2	cu	.4	10	1	700	3	W.T.J.
M-4	2000	1 June 56	24.5	22W	26654	ch. 550	12kts	85	185	240	1	65	70	30.28	2	cu	.5	5	1	650	4	W.T.J.
M-5	2400	2 June	24.5	22W	2656	ch. 600	12kts	80	181	240	1	64	69	30.30	1	cu	.3	5	1	900	5	W.T.J.

Figure 5–10.—The BT log sheet.

Column 9—SURFACE TEMPERATURE READING: Enter the temperature in degrees and tenths of a degree Fahrenheit. Whenever thermometer corrections are known, enter the corrected temperature only, followed by C.

Caution.—The surface temperature is of little value unless taken within 5 minutes of the start of lowering the BT.

If the surface temperature was taken 5 minutes or more before or after this time, enter as a note on the back of the sheet the time when it was taken. Record the surface temperature while the BT is lashed in its rack. Obtain the surface temperature from the injection thermometer, but do NOT get the temperature from the hourly entries on the engineer's log. The temperature to the nearest tenth of a degree can be obtained from a bucket of surface water.

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Column 10—INJECTION (I) OR BUCKET (B): If the temperature was taken from water collected in a bucket, enter B; if from the injection thermometer, enter I.

OBSERVATIONS WHICH MAY BE COPIED FROM DECK LOG IF CONDITIONS HAVE NOT CHANGED

Column 11—WIND DIRECTION: Enter the true direction, to the nearest compass point or in degrees, from which the wind blows.

Column 12—WIND FORCE: Enter proper number from Beaufort's scale. Make a note if anemometer is used.

Column 13—AIR TEMPERATURE—DRY BULB: Enter degrees and tenths of a degree Fahrenheit as read from the ship's dry bulb thermometer. If thermometer corrections are known, enter corrected temperature followed by C (example, 48.2°C.). The time of dry and wet bulb readings should be shown in a note, if taken more than 15 minutes before or after lowering.

Column 14—AIR TEMPERATURE—WET BULB: (Same procedure as for dry bulb.)

Column 15—BAROMETER: Enter inches of mercury to hundredths of an inch. Enter corrected reading, when corrections are available, followed by C; thus, 28.98 C.

Column 16—WEATHER SYMBOL OR SYMBOLS: Use as many of the deck log "state of the weather" symbols as necessary for clear description of the weather.

Column 17—CLOUDS, FORM: Use as many deck log symbols as necessary to indicate clouds actually seen.

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Column 18—CLOUDS, AMOUNT: Observer should estimate the amount of cloud coverage at time of lowering, in accordance with deck log instructions.

Column 19—VISIBILITY: See deck log instructions. Enter the proper number.

Column 20—SEA. See deck log instructions. Enter the proper number for "sea condition."

COLUMNS FOR OBSERVER'S USE

Column 21—BT DEPTH: Enter depth (in feet) of the lowest point on the trace as read in the viewer.

Column 22—SAMPLE NUMBER: This column applies only when surface water samples are collected.

FURTHER INSTRUCTIONS

For uncertain observations and when no observation was made, the space should be LEFT BLANK. Do not use a dash.

Notes should be written on the back of the sheet. Each note should begin with the slide number to which it refers, or the time of observation. Here are some typical notes:

1. "Slide 10—BT struck hull while lowering; uninjured."
2. "Slide 6—Seaweed lined up on surface."
3. "Slide 7—BT lowered near strong riptide."

Use a pencil and write clearly.

Be sure to look at Directions for Keeping the Ship's Log in the front part of the regular deck log book. Notes should be made on the back of the BT log sheet covering any unusual phenomena observed. Look at the types mentioned in the Synopsis section, paragraphs 1–6, 9, and 24 of Directions.

Whenever a new BT is used, a record of the cable out (by seconds or counter revolutions) at each lowering may be entered in the last two columns of the log sheet in order that graphs, like those shown in figures 5–8 and 5–9, may be constructed.

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When routine weather observations have been taken, but the BT is not lowered within roughly half an hour, list the observation information in the appropriate columns, but leave blank the spaces for slide number, BT number, etc. Time of observations and date should always be properly entered.

After the slide has dried in the box, the actual depth reached should be determined and entered on the log sheet. After a number of lowerings at different speeds, the suggested graphs of BT depths attained for a given number of revolutions of cable out may be plotted from the entries of speed, cable out, and BT depth.

SUMMARY OF WHAT TO DO

1. Obtain permission from the officer of the deck to lower the BT.
2. Fill in log sheet except for surface temperature, time, speed, and BT depth.
3. Determine depth of the water and estimate amount of cable to be run out.
4. Load BT with slide.
5. Measure surface temperature, and enter on the BT log sheet.
6. Tow BT at surface for 30 seconds, and set revolution counter.
7. Lower and raise BT, noting number of revolutions of cable out.
8. Remove, wash, label, and lacquer the slide, place in box to dry, and CLOSE THE BOX COVER.
9. Complete the BT log sheet and write down any corrections and notes.
10. Plot or check graph of BT depth versus revolutions of cable out.

SUMMARY OF WHAT NOT TO DO

1. Don't lower the BT when ship is expected to turn, or when other ships are too close astern.

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2. Don't lower the BT unless you know the water is at least 25 feet deeper than you expect the BT to go.
3. Don't bump, drop, or jar the BT. It is a delicate instrument.
4. Don't use a cable with bad kinks in it. If kinks occur that cannot be straightened EASILY, the cable should be cut off and reattached to the swivel.
5. Don't leave the BT in a place where its temperature may go above 105° F.
6. Don't guess at an observation. If the correct information is not available, leave the space blank on the BT log sheet.
7. Don't turn the motor switch on or off while the motor has any load on it.
8. Don't try to use a bad slide. If a slide is smoked on the wrong side, too thinly smoked, or badly spotted or flaked, throw it over the side.

LABELING BT SLIDES

As soon as possible after the BT has been raised, the slide should be removed, dipped in fresh clean water, labeled, dipped in lacquer mixture, and stowed in the slide box to dry. The information must be printed clearly on the smoked surface with a sharp pencil, before lacquering the slide, either to the right or the left of the trace. Leave a good margin between the printing and the edge of the slide. Do not touch the trace while printing. When printing hold the slide with the smoked surface upward and make sure that the surface trace is at the top of the slide.

Look at figure 5–11. On each slide there are four lines of information that will make sense to you as soon as you know the code.

Here's the information that must be written on each of the four lines:

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First line:

SLIDE NUMBER: Number the slides consecutively during each cruise. If own ship is at sea for 2 weeks and 40 slides are used, number the slides from 1 to 40 (same as column 1 on log sheet).

TIME GROUP: The Greenwich mean time (0000 to 2400) at which the BT was lowered into the water. Show the approximate minute at which the BT entered the water (same as column 2 on log sheet).

Second line:

DATE: Month, day, year must be in numbers as shown in figure 5–11. The date changes after 2400 GMT. The month should be written in Roman numerals (column 3 on log sheet).

Third line:

LATITUDE AND LONGITUDE: Entered to the nearest whole degree. Again check with figure 5–11 for manner in which this is written (columns 4 and 5 on log sheet).

Fourth line:

BT NUMBER: The serial number of the BT used, found stamped near the nose of the instrument (column 6 on the log sheet).

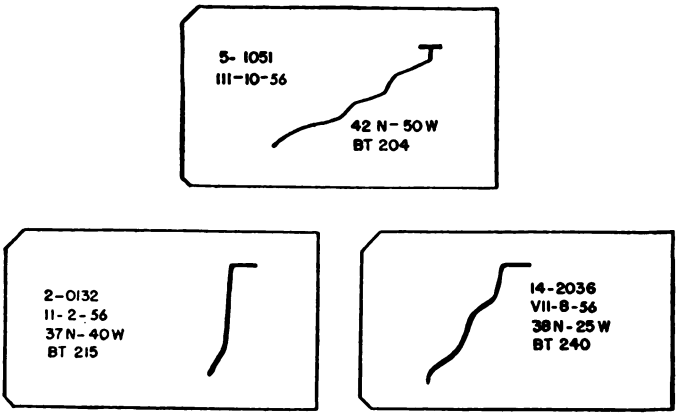

Figure 5–11.—Labeling the BT slide.

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After labeling the slide, dip it once in lacquer, drain off the excess lacquer against the edge of the lacquer jar, and immediately place the slide in the slide box and close the box. (See fig. 5–12.)

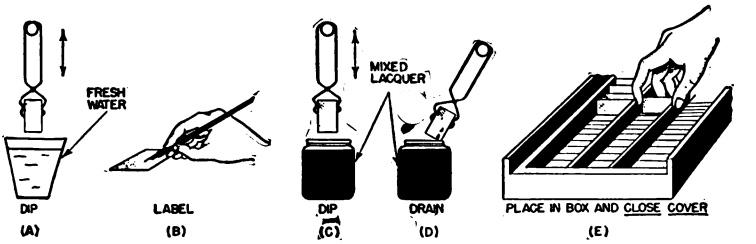

Figure 5–12.—The lacquering process.

The slide should be left in the box until it is thoroughly dry. If the slide dries in moving air, the lacquer often turns white and makes the slide difficult to read. A fogged slide can be cleared, however, by relacquering it after it has dried.

A dipping tweezer is provided for washing and lacquering the slides. The slides should always be handled carefully, especially if they are to be viewed before lacquering. Then lacquer them as soon as possible after viewing. Close the jar of lacquer immediately after using because lacquer evaporates rapidly and is highly inflammable.

Lacquer marked "Ready Mixed," sent with BT equipment, is approximately the correct consistency for lacquering slides. To avoid losing large amounts of the ready-mixed lacquer by evaporation, pour just enough lacquer from the main can into the jar to cover a slide dipped endways into it.

When the lacquer in the jar gets too thick, pour it out and replace with a new quantity of the ready-mixed lacquer.

If the supply of ready-mixed lacquer is used, mix Navy

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issue clear lacquer with Navy issue lacquer thinner in the proportion of about 3 parts thinner to 1 part lacquer.

The consistency of the lacquer mixture in the main can should be tested at intervals by dipping an unused slide in it and then letting the slide dry in the box. After drying, the lacquer should be perfectly transparent, hard, even, and just thick enough to protect the smoked surface from being scratched during ordinary handling. If evaporation has occurred, the coating on the slide will be thick and uneven. Thinner should then be added to the mixture in the main can.

How to View The Slide

Set the slide loosely in the holder, as illustrated in figure 5–13A, with the smoked surface down and the beveled corners on the left side just clearing the stop pin. Hold the assembly as shown in figure 5–13B and, with a thumb

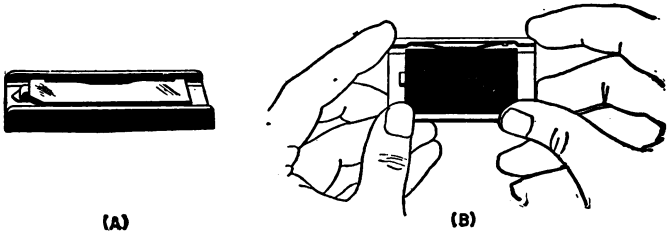

Figure 5–13.—Inserting slide in viewer.

motion like that used in rolling a cigarette, push the slide against the spring until the slide drops flat against the grid. Then push the slide to the left firmly against the stop pin. The smoked surface should lie smoothly against the grid.

This method is especially good when unlacquered slides must be put in the holder. It prevents the grid from scratching or rubbing against the smoked surface. When the holder and slide are placed in the viewer, make sure that the slide is kept tight against both the stop pin and

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the groove opposite the spring. Otherwise, temperature and depth readings will be incorrect.

If the grid becomes loose in the holder, recement it. Be careful to apply cement only to the face of the grid. Check to see that the narrow edge of the grid is tight against the stop pin, and that the long edge (the zero pressure edge) is tight against the edge of the holder opposite the spring. The spring is narrow and placed in such a position that the grid fits behind it. As a result, the spring bears on the slide and holds it snugly without pressing on the grid.

BT VIEWER AND GRID

The trace scratched by the stylus is a temperature-depth curve. Each point on the trace represents the temperature at a given depth. Temperature and depth values are read from the curve on the slide. Temperatures should be read to tenths (0.1) of a degree; depths should be read to within 10 feet or better on the 900-foot BT, 5 feet or better on the 450-foot BT, and 2 feet on the 200-foot models.

Each BT has its own grid, which must be used in reading slides made with that BT. The grid carries a number indicating the BT for which it is designed. See figure 5–14 for an example of a BT slide in a grid and a viewer.

Place the slide back of the transparent glass grid, which is ruled off in temperature and depth scales. The slide should be held back of the grid in the same position it had in the BT. Place the slide in the viewer slide holder, to which the grid is cemented, then insert the viewer slide holder in the viewer, which has an adjustable eyepiece. This eyepiece brings the curve and scales into proper focus. Handle the grid carefully. Each BT has two identical grids in individual holders, one to be used as a spare.

HYSTERESIS

The stylus scratches its curve both while the BT sinks and as it rises. Water conditions where it sinks may be slightly different than where it rises, but these differences

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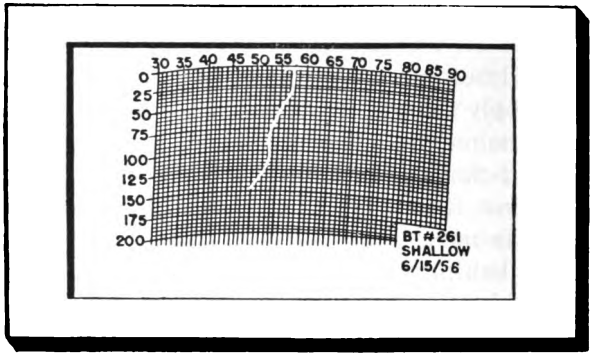

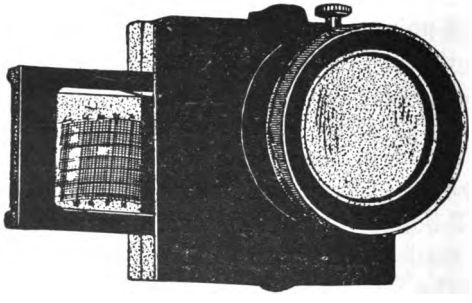

Figure 5–14.—The grid's serial number corresponds with the BT's serial number.

are usually slight. Also, the instrument may have HYSTERESIS; that is, there may be a slight lag in the movement of the stylus because of friction or other causes. This may cause a separation of the traces. If the up-and-down traces are essentially similar, a slight separation of the traces does not make much difference. If it is suspected that the instrument has hysteresis, insert a fresh slide in the BT and make a second quick lowering. A brief inspection of the slides will tell if water conditions changed during the two lowerings. If water conditions were the same and the BT has hysteresis, the two slides will be the same, each showing two similar traces which follow each other.

The lag of the stylus may be caused by the temperature

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element of the BT. In this case, the stylus arm does not record the exact temperature position as the BT sinks and rises. Thus, at a given depth, the pen at one point is going down and at another point is coming up. The temperature at the given depth, if water conditions are the same, would be a point between the two traces.

READING SURFACE TEMPERATURE

When the BT is on the deck, it usually has a different temperature than when put into the water. The temperature element will move the stylus along the zero depth line of the surface water temperature position during the 30 seconds or more when the BT is towing at the surface. So, the top of most traces is an almost horizontal line. This surface trace should fall along the zero depth line of the grid when the slide is viewed. If it appears more than 3 feet above or below, correct the depth readings by the amount of this error. Read surface temperature by noting the point at which the trace starts downward from the surface trace.

It's a good idea to make a comparison from time to time between the surface temperature as read from the slide, and the surface temperature as read for the same lowering on the injection thermometer. On a series of slides taken from the same BT, the difference between the slide and the thermometer surface should be about the same. If there is a difference, and if the difference continues for later lowerings, the calibration of the BT has probably shifted. A shift in calibration, sometimes called a shift in the zero points, usually does not change the accuracy of the BT. But, make a note on the BT log sheet showing the slide number and the time at which a shift in calibration was detected.

If the BT strikes either the ocean floor or an underwater object, the depth at which it struck can be determined by reading the depth of the horizontal line across the trace, made when the stylus arm vibrated with the shock.

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As already pointed out, the bathythermograph provides a continuous visual record of the temperatures from the surface of the sea to a depth to which it is lowered. And the temperatures of various ocean depths discovered by the BT are represented as a graph on the slide. A typical example is shown in figure 5–15.

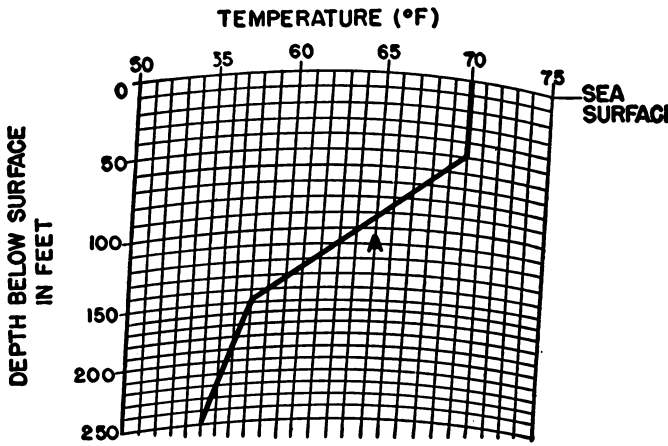

Figure 5–15.—Learn to interpret the BT slide.

In figure 5–15 the line marked "A" represents changes in temperature between the sea surface and a depth of 250 feet. There is little change in temperature until a depth of 50 feet is reached. At that point, the temperature of the water begins to cool quite rapidly to a depth of 150 feet. Below 150 feet, the water cools more slowly.

From the temperature curve, one can discover the maximum echo range and the particular SOUND PATTERN of the sea at the time of the bathythermograph observation.

The variation of temperature with depth can be very complicated, and a large number of different cases will be represented by the different bathythermograph slides. It

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is convenient to consider the water as layers. In each layer the temperature can change from top to bottom.

Create a mental picture of the location of these layers from the appearance of the slide. Visualize, too, how the temperature is changing. Study the following examples until each kind of layer can be identified easily.

Isothermal Layer

An isothermal layer is a layer (not necessarily at the surface) in which the temperature is the same all the way from the top to the bottom. ISOTHERMAL may be remembered as meaning SAME TEMPERATURE. The water must be well mixed from the top to the bottom of the layer for the temperature to be the same throughout. Therefore the name MIXED LAYER is also used. Mixed layers are important, and Sonarmen must be able to read accurately the top and bottom depths of such a layer. Look at figure 5–16. The isothermal layer is the section of crossed lines. Note how the bathythermograph trace in these areas is a straight up-and-down line.

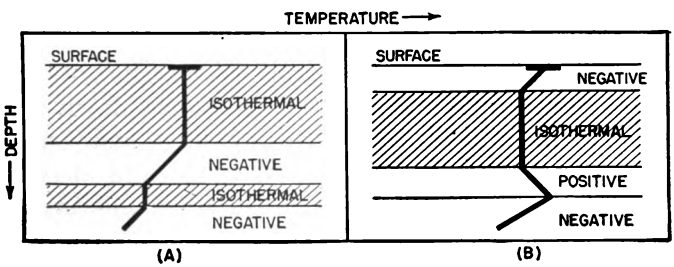

Figure 5–16.—Ranges are long in the isothermal layer.

Every time a straight vertical bathythermograph trace is seen, the layer of water at that depth is known to be ISOTHERMAL.

Negative Gradient

Next in importance to an isothermal layer is a layer in which the temperature DECREASES with increasing depth.

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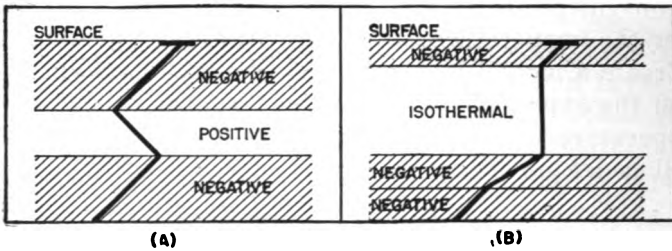

Figure 5–17.—Negative gradients lead to short ranges.

In this case, the bathythermograph trace will slope to the LEFT, looking down from the top of the layer toward the bottom. This decrease of temperature with depth is also called a NEGATIVE GRADIENT. In figure 5–17, the layer of negative gradient is indicated by crossed lines. Sections of the bathythermograph trace which slant downward and to the left indicate layers of water in which the temperature decreases as the depth increases. Between the negative layers in figure 5–17A, there is a layer having a positive gradient; and in figure 5–17B is an isothermal layer between the two layers of negative gradient.

Positive Gradient

Layers in which the temperature INCREASES with depth are sometimes found. Here the trace slopes down and to the right. This is called a POSITIVE GRADIENT, and is usually observed in coastal waters but may be found anywhere. Sample trace diagrams for this case are illustrated in figure 5–18.

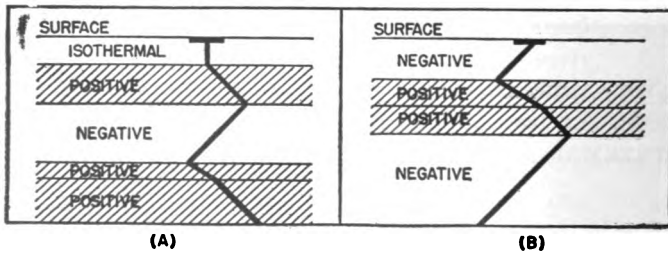

Figure 5–18.—Positive gradients mean very short ranges.

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The layers in which the temperature increases with depth are marked by crossed lines. Sections of the trace which slant downward and to the right indicate layers in which the temperature increases as the depth increases. Look at figure 5–18A. Reading downward from the surface, there is an isothermal layer, then a positive, a negative, a positive and another positive gradient layer. Reading downward from the surface in figure 5–18B, there is a negative, a positive, a positive, and a negative gradient layer.

DAILY HEATING

Daily heating of the surface water layer has a marked effect on sonar ranges. It produces a condition A/S men call "afternoon effect."

When the surface is heated by the summer sun and the winds are not strong enough to keep the surface water well mixed, the water close to the surface may be several degrees warmer than the water 20 to 30 feet down. This effect is maximum in the late afternoon, and usually disappears at night as the surface cools off and water continues to mix. Figure 5–19 is a simplified illustration showing how traces on a series of slides may indicate

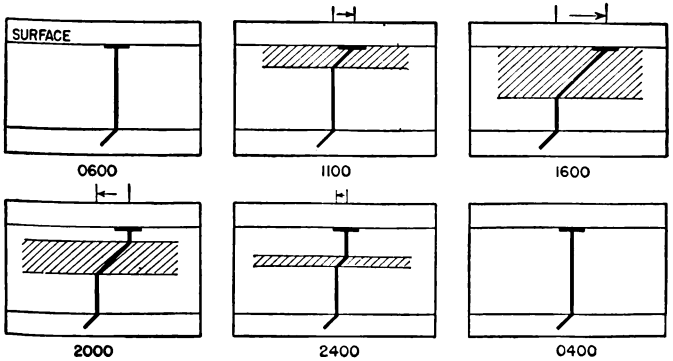

Figure 5–19.—Surface heating destroys the isothermal layer.

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daily heating or cooling near the surface. An isothermal layer is shown at 0600 (local time) on a calm clear day.

From 0600 to 1600 the surface is shown gaining heat from the sun faster than it can dissipate the heat back into the atmosphere. The surface temperature increases, and a negative gradient layer, shown by the crossed lines, is established. This layer deepens as the heat penetrates, and diffuses downward by conduction during the time the surface is gaining heat.

After 1600 the surface is shown cooling off by evaporation faster than it receives heat from the declining sun. The cooler and denser surface water mixes and may destroy the negative gradient layer. Sufficient cooling may occur during the night to reestablish a single isothermal layer, as shown at 0400.

BT MAINTENANCE

Thus far in this chapter a great deal has been said about care of the BT. Details of BT maintenance are important, and some of them are repeated here for emphasis.

The bathythermograph is an accurate measuring instrument, and, while the construction is reasonably rugged, the internal mechanism is delicate. Careful handling is essential for maintaining the accuracy of the measuring elements. Avoid damage to the capillary, as the smallest leak in this system will make the BT inoperative.

The temperature of the BT must NOT exceed 105° F. In moderately hot weather, install the rack so that the BT is held upright with the thermal element and fins resting in a bucket of water. The temperature usually can be kept below 105° F. by dipping a white cloth in the water, then wrapping the cloth around the exposed part of the bathythermograph, changing the water frequently. However, it is best, especially in the tropics, to have the BT on deck only long enough to make a lowering and then return it to the coolest convenient place.

Rinse the interior of the BT twice each week with half

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a cupful of grade III rust-preventive compound. Draw a gallon from the supply officer. Ask for Navy specification 52–C–18. Place the BT in a clean bucket with tail fins down. Slide the sleeve up, pour in half a cupful of grade III rust-preventive compound, and close the sleeve. Then, holding both hands over the small openings in the body tube, shake the BT up and down and turn it over on its nose and back several times so that every part is thoroughly covered. Let the cleaning fluid drain out. The cleaning fluid can be used several times without harm. It may be applied with a small spray gun operated energetically until the BT "smokes" from every opening. This cleaning process will prevent the sea salt from caking and damaging the BT.

The bathythermograph should be cleaned from time to time, usually ashore after a cruise. Tie rod nuts and clamps should first be loosened, and the tail fins, thermal assembly, and nosepiece assembly should be carefully removed from the body tube. Remove any silt, seaweed, etc., that may be found. Check moving parts for corrosive action. DO NOT CLEAN THE BELLOWS ASSEMBLY WITH BRIGHTWORK POLISH because the chemicals contained in such polishes have a detrimental effect on the bellows. Usually, all the cleaning materials needed are a soft paint brush and clean fresh water. In reassembling the nosepiece assembly and the thermal assembly into the body tube, give each a slight back-and-forth motion to make certain that the shoulders on these pieces butt tightly against the body tube.

BT records can be read to 0.1° F. on the temperature scale and to 10 feet or better on the 900-foot BT, 5 feet or better on the 450-foot BT, and 2 feet on the 200-foot BT depth scale. Shocks which occur to the instrument during handling and lowering may shift the temperature and pressure zeros. In order to determine the amount of correction to apply, use the following RECALIBRATION process.

To check for temperature error, load the BT with a slide, but leave the brass sleeve up so that the stylus is not

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against the slide. Put the BT in a bucket and pour in just enough water to cover the fins and thermal element up to the sleeve. After the BT has remained in the water several minutes, push the sleeve down so that the stylus may mark the slide. Read the temperature of the water with an accurate stem thermometer.

Next, raise the sleeve, but don't take the BT out of the bucket. Add enough hot water to raise the temperature several degrees. Allow the BT to come to temperature, push down the sleeve, measure the temperature, and push up the sleeve again. Repeat this process several times so that a series of temperature points can be established across the slide, along the zero pressure line. Then plot these temperature points on a graph against the temperatures obtained from the stem thermometer. Values of the points, of course, will be read by placing the slide in the grid in the usual manner.

Check for depth error by immersing the BT temperature element first in a cold and then in a warm (less than 105° F.) bucket of water. This will cause a long zero pressure line to be drawn across the slide. Then place the slide back of its grid, and see if the trace is on the zero pressure line on the grid. The difference between the zero pressure line on the grid and the slide, measured in feet, is the DEPTH ERROR. The error may be plus or minus, and must be corrected on all depth readings.

Results from the above methods are, at best, approximate. They are suggested only as a makeshift in the absence of better test equipment. Any instrument found seriously in error should be returned to the laboratory for adjustment. A small shift in calibration does not destroy the usefulness of the instrument, however. The way in which the temperature changes with increasing depth is the important thing. To determine if a BT is no longer useful, compare the temperature changes between depths (as shown on the slide from a suspected BT) with the changes shown on the slide of another BT lowered in the same water.

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WINCH MAINTENANCE

Long periods of trouble-free operation can be expected from the equipment if it is kept clean, lubricated regularly, and inspected occasionally for signs of impending wear. Refer to the instruction book for the type of winch aboard.

Adjustments

The only adjustments provided on the hoist are for the clutch and brake. Conditions for proper operation are such that, with the operating lever in the neutral position, the brake must be completely off, and the clutch must be slipping freely. If these conditions are not met, follow instructions in the paragraphs below.

CLUTCH.—The clutch may be adjusted at either of two points: at the adjustable ring on the clutch itself, or at the crank connector. The ring should be used, if possible, to lessen chances of upsetting other adjustments. Other adjustments are as follows:

1. Set the operating lever to neutral.
2. Loosen the two setscrews on the clutch adjusting ring.
3. To disengage the clutch further, back off the ring slightly; to make the clutch tighter, screw the ring in slightly. A quarter turn in either direction is usually sufficient.
4. Tighten the setscrews.

BRAKE.—The brake must be loosened if it drags when the operating lever is in neutral. It must be tightened if proper control cannot be obtained when the operating lever is breaking. Follow the steps listed below.

1. Back off the jam nut.
2. To loosen the brake, back off hex nut the required distance and set the jam nut.
3. To tighten the brake, tighten up on the hex nut the required distance and set up the jam nut.

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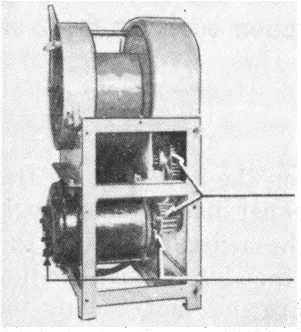
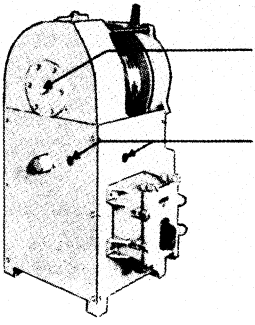


SA VV-L-751—FOUR GEARS AND WORM ON DRUM FLANGE — REMOVE COVER PLATES — APPLY THIN FILM TO TEETH WITH FINGERS — AVOID GETTING GREASE IN CLUTCH.

SA 14L3—HOIST MOTOR BEARINGS—REMOVE DRAIN PLUGS BEFORE GREASING —FILL CUPS — SCREW DOWN CUPS WHILE SPINNING SHAFT AND BEFORE REPLACING DRAIN PLUGS.



M 14L3 — CABLE REEL SHAFT BEARING AND WORKING PARTS — FILL CUP AND SCREW DOWN COMPLETELY.

M M. S. 3042 — SPRING CAP OILERS FOR INTERMEDIATE GEARS' SHAFT — USE OIL CAN SPOUT THROUGH TWO HOLES IN COVER PLATES — FILL CUPS LEVEL FULL.

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M MONTHLY

NAVY LUBRICANT		STANDARD NAVY STOCK NUMBER						NEAREST COMMERCIAL LUBRICANT
SPECIFICATION	TITLE	5-GAL.	55-GAL.	1-LB.	5-LB.	25-LB.	100-LB.	
14L3	Lubricating mineral grease			14-L-84-900	14-L-84-910			Medium bearing grease
MIL-O-15016 3042 M.S. 3042	Lubricating oil	14-0-2565-65	14-0-2565-10					SAE No. 10 motor oil
VV-L-751	Gear lubricant					14-L-171-25	14-L-171-100	Texaco Crater No. 1 or 2

Figure 5–20.—Lubrication chart.

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Lubrication

Approximately every 6 months, the cover plates should be removed and a heavy water-resistant grease applied sparingly to the gear teeth. A small quantity should be applied also to the large worm teeth that drive the counter gear train. These worm teeth are machined in the drum flange outer diameter on the clutch end of the drum. This and the counter mechanism can run dry of lubrication for long periods without injury. Avoid excessive greasing, to prevent grease entering the clutch where it will interfere with smooth operation. Figure 5–20 shows the other points to grease monthly or semiannually, and the type of grease to use on each fitting.

GENERAL CHECKLIST

Observe the following general steps for proper care and maintenance of equipment.

1. Inspect towing sheave daily for grooves cut by the wire cable. Reverse sheave to equalize wear; replace when worn on both sides.
2. Inspect and clean equipment weekly.
3. Wash unit down with fresh water whenever possible.
4. Inspect winch monthly for corroded spots. Scrape clean, where necessary, and repaint.
5. If the cable becomes kinked, remove the kinked section and refasten the wire cable.
6. Order replacements immediately for spare parts and supplies that are used.
7. When not in use, protect the winch at all times with the canvas cover provided.

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QUIZ

1. What is the significance of the trace scratched by the BT stylus?
2. How often should BT readings be taken?
3. What factor most affects the depth at which a BT rides when lowered?
4. What is the condition of the water when traces show isothermal layers?
5. What is the maximum temperature to which the BT can safely be submitted?
6. If any part of the tube of the thermal assembly becomes inoperative or punctured, what happens to the trace?
7. How closely, in feet and degrees, should the 450-foot BT be read?
8. What cleaning agent is used for the BT?
9. What is the purpose of the BT?
10. How can an accurate reading of the surface temperature be obtained?
11. Why must the OOD know that the BT is being lowered?
12. If there is a kink in the cable, what should be done?
13. How can one tell that the BT is near the surface when hoisting?
14. Where are completed slides shipped?
15. What series of BT's follows the OC–B/S series?
16. Which BT's do not have the stylus lifter?
17. What is the temperature range of the BT?
18. How many feet of copper tubing are connected to the Bourdon tube assembly?
19. What is this tubing filled with?
20. What are the two principal inside assembly parts of the BT?

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CHAPTER 6

SONAR EQUIPMENT

The echo-ranging sonar set is the key equipment in surface ship antisubmarine warfare. The operator's position is the control indicator, more popularly called the console, located in a space called sonar control. Most of the training you receive will be directed toward operation and maintenance of this equipment.

Sonar (and associated electronic equipment) is designated by either the AN nomenclature (naming) system or the older Navy model letter system.

AN NOMENCLATURE

On the front of each item of sonar equipment is a nameplate carrying a group of letters and numbers identifying the set. A group of this type is assigned to all new electronic equipment procured by the Navy, Army, or Air Force.

The first two letters, AN, signify the system indicator. This does not mean that all three services use the equipment, but only that the type number was assigned under the AN system.

AN is followed by a slant sign and three identifying letters. Letters to the right of the slant sign are very important, for they give a brief description of the equipment.

FIRST LETTER—Where installed: whether meant for use in water surface craft, submarine, air craft, etc.

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SECOND LETTER—Type of equipment: underwater sound, radio, radar, etc.

THIRD LETTER—Purpose of equipment: detecting and/or range and bearing, receiving or listening, communicating, etc.

The equipment indicator letters and their meanings are listed in the table below.

Equipment Indicator Letters, AN Nomenclature System

Installation	Type of equipment	Purpose
A—Airborne (installed and operated in aircraft).	A—Invisible light, heat radiation.	A—Auxiliary assemblies (not complete operating sets).
B—Underwater mobile, submarine.	B—Pigeon.	B—Bombing.
C—Air transportable (inactivated).	C—Carrier (wire).	C—Communications (receiving and transmitting).
D—Pilotless carrier.	F—Photographic.	D—Direction finder.
F—Ground, fixed.	G—Telegraph or teletypewriter (wire).	G—Gun directing.
G—Ground, general ground use (includes two or more ground installations).	I—Interphone and public address.	H—Recording (photographic, meteorological, and sound).
K—Amphibious.	K—Telemetering.	J—Countermeasures (receiving and transmitting).
M—Ground, mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment).	M—Meteorological.	L—Searchlight control.
P—Ground, pack or portable (horse or man).	N—Sound in air.	M—Maintenance and test assemblies (including tools).
S—Water surface craft.	P—Radar.	N—Navigational aids (including altimeters, beacons, compasses, instrument landing, and depth sounding).
T—Ground, transportable.	Q—Underwater sound.	
	R—Radio.	
	S—Special types, magnetic, etc., or combinations of types.	
	T—Telephone (wire).	
	V—Visual and visible light.	
	X—Facsimile or television.	

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Installation	Type of equipment	Purpose
V—Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment—such as tanks). U—General utility (includes two or more general installation classes, airborne, shipboard, and ground). W—Underwater, fixed.		P—Reproducing (photographic and sound). Q—Special, or combination of types. R—Receiving or listening. S—Detecting and/or range and bearing. T—Transmitting. W—Remote control. X—Identification and recognition.

An example of AN nomenclature in sonar is AN/SQS–10. From the table you get the following meanings for the descriptive letters:

S—Installed in water surface craft;
Q—Underwater sound gear;
S—Detecting and/or ranging and bearing equipment.

The AN/SQS–10 is an azimuth search sonar set for use aboard surface ships. The figure 10 is the model number.

The AN nomenclature system came into use in 1946, but you will still find equipment marked and identified by the old Navy model letter system. Equipment designated by model letter is cited in this chapter, but the system will not be explained because its use has been discontinued.

ECHO-RANGING SONAR

All types of echo-ranging sonar sets operate basically the same. A signal is transmitted, an echo or noise is

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received, and the results are presented at the console in sonar control, and at remote stations. Searchlight equipment provides audio information only; azimuth search equipment provides both audio response and video display.

Sonar Frequencies

Azimuth sonars have pulse-type transmitters operating on fixed frequencies, either 20 or 25.5 kcs. The first successful azimuth sonar was model QHB–1, later modified to become QHBa. QHBa sonar sets, operating on a frequency of 25.5 kcs, are still in general use in the fleet.

Further modification of the QHBa produced a group of sonar sets designated as AN/SQS–10, –10A, –11, and –11A. As you can see in the table below, sonar sets in this group differ in frequency and power output.

Equipment	*Operating frequency (kcs)*	*Energy per pulse (watt seconds)*
AN/SQS–10	20	250
AN SQS–10A	20	800
AN/SQS–11	25.5	250
AN/SQS–11A	25.5	800

Although newer sonars are on the way, AN/SQS–10 and –11 sets, and model QHBa are the ones in general use. Searchlight sonars remain in harbor defense, on ships of the Reserve Fleet, and in some Naval Reserve training centers.

Sonar set components to be discussed here are in the AN/SQS–10 and –11 series. Where these components differ significantly from model QHBa, the differences will be indicated.

Sonar Set Components

Components of the AN/SQS–10 and –11 series sonar sets include one each of the following:

Control indicator;

Sonar transmitter;

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Sonar transducer;
Transducer transfer switch;
AF–RF amplifier (SQS–10 and –10A);
RF amplifier (SQS–11 and –11A);
Receiver-scanning switch assembly;
Signal data converter;
Voltage regulator.

In addition to the above, two azimuth range indicators (remote indicators), three loudspeakers, and three headsets are provided. Components in Sonar Set AN/SQS–10 and interconnecting cables are shown in figure 6–1.

Sonar Cables

Cables connecting components of sonar equipment are classified according to type of insulation and general features of construction. There are five general cable insulation classifications:

RUBBER-INSULATED cables for FIXED installations.
RUBBER-INSULATED cables and cords for FLEXIBLE use.
VARNISHED CAMBRIC-insulated cables.
HEAT- and FLAME-RESISTANT cables.
SILK-, COTTON-, and ENAMEL-insulated cables, cords, and wires.

All cables are identified by a standard system of lettering and numbering. By using these letters the type of cable covering, type of cable insulation, and number of conductors in the cable can be read easily. A number following the letters generally designates the size, but may stand for the number of conductors or the number of twisted pairs. A number in parentheses following the first number represents the number of strands in the conductor.

In addition to the number of conductors, the manufacturer generally specifies the number of ACTIVE conductors in sonar installations; remaining conductors are spares.

As an example of a cable marking, DHFA–4(7) means:
D—Number of conductors—(Duplex)—Two.
HF—Type of insulation—(Heat- and flame-resistant).

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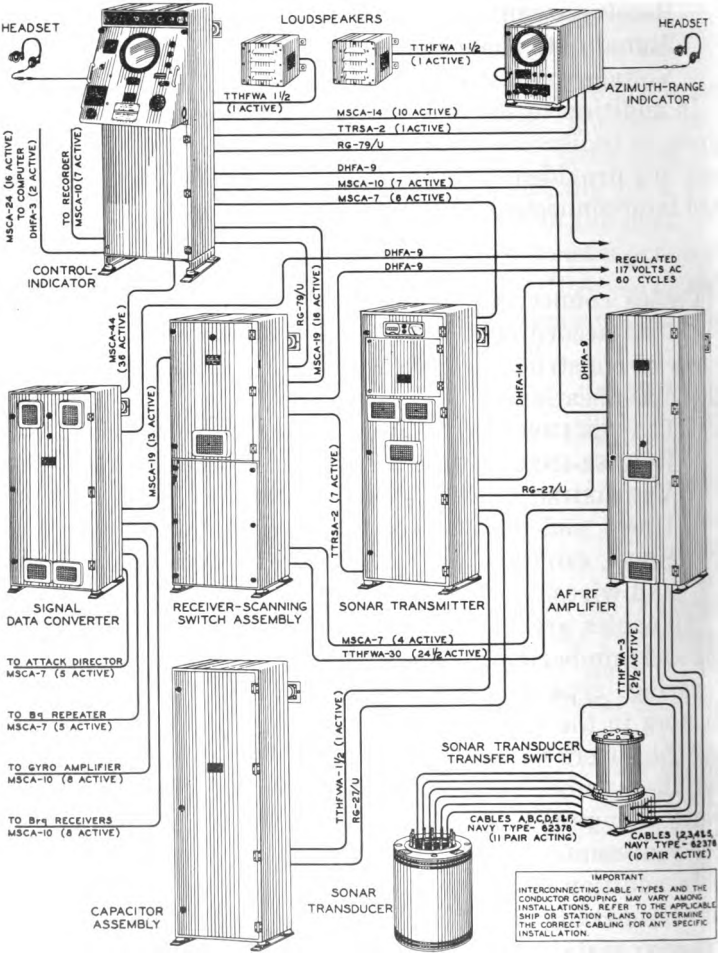

Figure 6–1.—Components of Sonar Set AN/SQS–10.

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A—Type of cable covering—(Armored)—Usually a braided metal sheath.

4—Total number of circular mils, in thousands, of all conductors (4 thousand).

7—Number of strands in each conductor.

If a cable is marked MHFA–19, it means:

M—Multiple—(Having more than one conductor).

HF—Type of insulation—(Heat- and flame-resistant).

A—Type of covering—(Armored).

19—Indicates 19 conductors within the cable.

In the second example, the manufacturer may have indicated MHFA–19 (13 active). This would mean that six of the conductors are spares.

Common types of interconnecting cable for sonar components include DHFA, TTHFWA (twisted pair, telephone, heat- and flame-resistant, armored), and TTRSA (twisted pair, telephone, radio, shielded, armored). The manufacturer's instruction book indicates the type of cable and conductor groupings for connecting various components, but you are cautioned that these will vary with different installations. It is always advisable to consult your ship's plans to determine the correct cabling for any installation.

THREE STEPS

The three steps of the underwater search process are transmission, reception, and presentation. A brief discussion of these steps will help you understand the operation of the sonar system. Trace the signal in the block diagram shown in figure 6–2.

Transmission

To transmit a sonar signal, the control indicator produces a keying pulse, its length determined by the operator. The keying pulse operates transmitting circuits, which generate a signal pulse. The signal pulse is next

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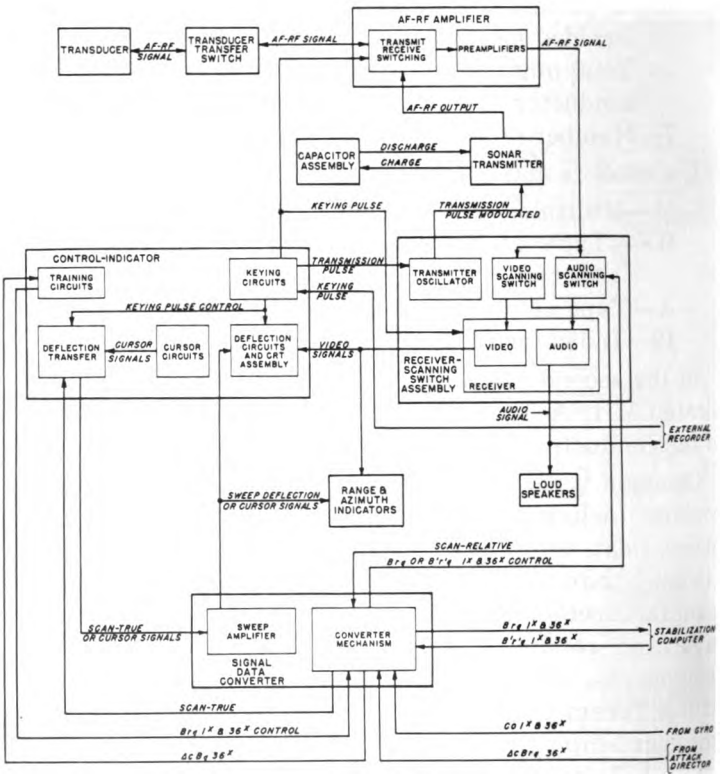

Figure 6–2.—Sonar system—block diagram.

amplified in the receiver-scanning switch assembly at a power level to furnish the input to the sonar transmitter, and in the transmitter, the pulse is amplified to produce the power level needed for transmission. The signal is launched into the water by the transducer, which converts electrical energy from the transmitter to acoustical energy, or sound.

A sound signal leaves the transducer like a thin-walled cylinder, expanding in diameter as it travels out. (See fig. 6–3.) The thickness of this "sound cylinder" depends upon the pulse length selected by the Sonarman.

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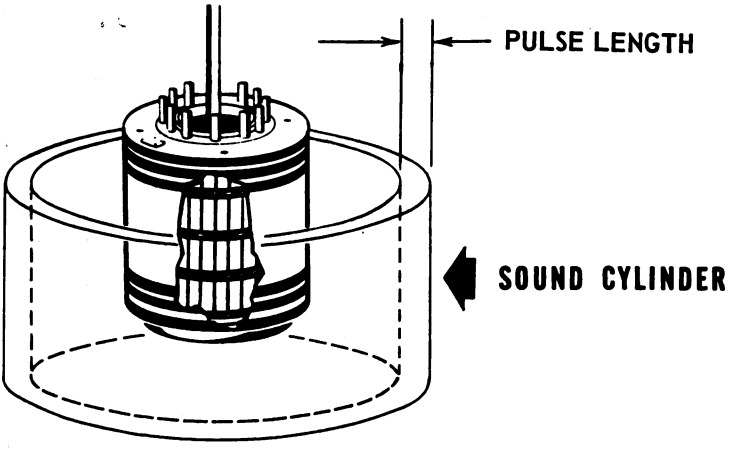

Figure 6–3.—Pulse length determines thickness of sound cylinder.

Reception

When the wave strikes an object that will reflect sound, a small part of the energy returns to the transducer, where it is converted from acoustic energy to electrical power. Any noise in the frequency range of the transducer will also be converted to voltages by the 48 elements of the transducer.

Each of the 48 signals from the transducer is fed by way of the transfer switch to an amplifier unit for preamplification by one of 48 preamplifier circuits. From the preamplifiers the signals are delivered to two scanning switches in parallel in the receiver-scanning switch assembly. Each scanning switch combines the voltages to produce a sharp beam pattern in a direction corresponding to the instantaneous position of each scanning switch rotor.

The audio switch produces a single beam pattern with its center directed at the instantaneous position of the audio scanning switch rotor. The video scanning switch produces a split beam pattern with two lobes, one on each

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side of the instantaneous position of the video scanning switch rotor.

The video scanning switch rotates continuously, sampling all echo or noise signals, producing short signal pulses as its beam pattern sweeps through the bearing of the target or noise source. These pulses are fed into the receiver video channels. The audio scanning switch, which does not rotate continuously but is controlled by the operator, feeds signals to the audio channel of the receiver.

Presentation

In processing the incoming signal for presentation at the control indicator, the receiver-scanning switch performs two jobs. It amplifies and converts the video signals for presentation on the cathode-ray screen, and it amplifies and converts the audio signal to the proper level and frequency to drive a loudspeaker.

The remainder of the task of displaying signal information is accomplished in the control indicator, more commonly called the sonar console. Transmission pulse, beam deflection of the cathode-ray tube, and screen brightening by received signals are functions performed automatically by circuits in the console.

THREE MODES OF OPERATION

AN/SQS–10 and –11 equipment can be operated in three ways: echo ranging at either of three range scales (1000, 3000, and 6000 yards); listening without transmitting and producing echoes; and echo ranging with a range gated sweep.

ECHO RANGING.—In echo ranging, the cycle commences with a line of light, or cursor, produced electronically on the cathode-ray scope. The bearing of the cursor is the bearing along which the audio scanning switch is trained. By adjusting the length of the cursor, you can read the range of any pip. Adjust the cursor until it just touches the pip, and read the range from the range dial.

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Pulse transmission takes place when the cursor is on the scope. You have a choice of three pulse lengths (6, 30, and 80 milliseconds). Remember, pulse length governs the thickness of the cylinder of sound leaving the transducer.

After the pulse is transmitted, the cursor disappears from the scope and an electron beam spirals out from the center of the screen. Sweep of the electron beam is synchronized with rotation of the video scanning switch in such a way that a returning echo will brighten the scope at a spot corresponding to the range and bearing of the object that produced the echo. Because the system is alert in all directions and echo indications remain for a

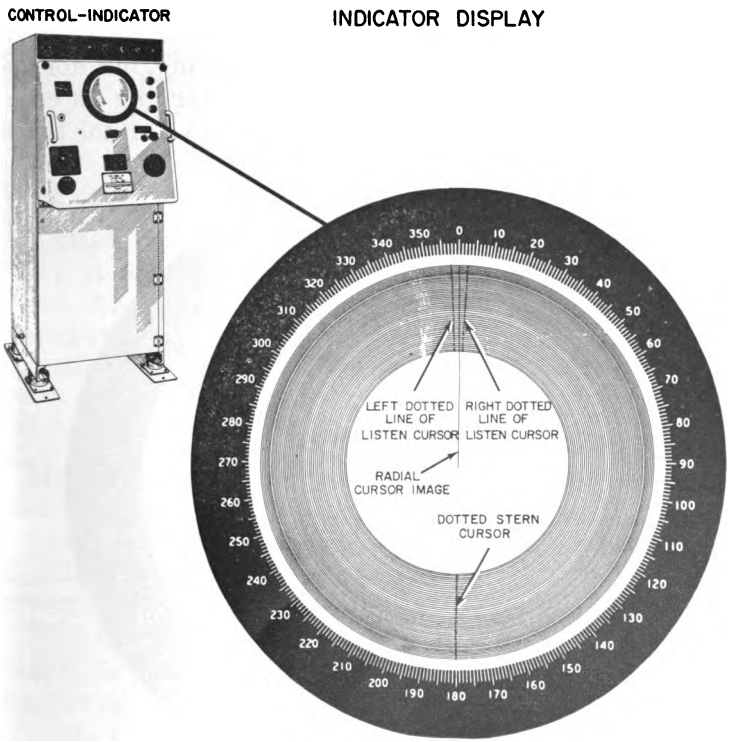

Figure 6–4.—Cathode-ray scope with equipment set for listening.

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time on the screen, the scope becomes a map of all echo-producing objects in the vicinity of the ship.

After each transmission, the scope dims (or blanks), the cursor reappears, and a new cycle begins.

LISTENING.—When the equipment is set for listening, the scope picture is a continuously oscillating spiral sweep, without blanking. This sweep occupies approximately the outer third of the screen, and a twin-dotted cursor, indicating the bearing of the audio scanning switch, remains on the scope. (See fig. 6–4.) Signals from an underwater noise source appear as a narrow radial line or a wedge of light on the screen. Bisecting the wedge with the cursor will give the bearing of the noise source.

When echo ranging, a continuous noise source (such as ship or torpedo screw noise) will also appear as a wedge of light on the scope. You can get the bearing, but not the range, because the noise source is not returning an echo. A noise source and a sonar target are shown on the scope in figure 6–5.

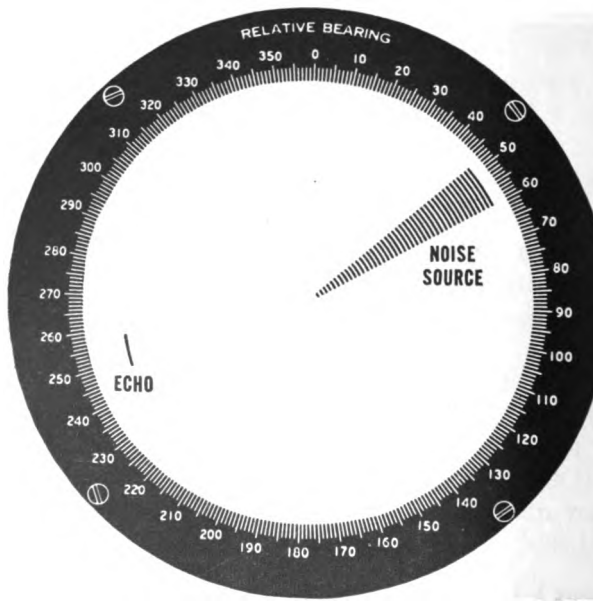

Figure 6–5.—Noise source bearing 054° and echo bearing 253° at 1400 yards.

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RANGE GATED SWEEP.—When the equipment is adjusted for range gated sweep operation, the bearing cursor remains on the scope for an extended period of time. The cursor remains on the scope until a point is reached that is 300 yards before the expected time of arrival of the echo. At that point, the cursor disappears and the spiral sweep commences. For instance, if you had the cursor adjusted for a target range of 1000 yards, the cursor would disappear and the spiral sweep would commence at 700 yards, 300 yards short of the target. Range gated sweep also spreads the target pip in bearing, thus making it easier to bisect.

When the equipment is adjusted for range gated sweep, the keying pulse starting the transmission comes from the OKA–1 or AN/SQA–4 range recorder. (These recorders are similar to the tactical range recorder to which you were introduced in chapter 2. You will study them in detail in chapter 9.)

TRANSDUCER

A clear picture of the design and functions of the transducer is an important key to understanding the principles of azimuth search sonar. Sonar transducers convert electricity to sound, and vice versa, in one of two ways: by magnetostriction or piezoelectricity.

Magnetostriction

Magnetostriction is a rather simple change that certain metals will go through when placed in a magnetic field. If a nickel tube, for instance, is placed in a magnetic field, it will change length as a result of MAGNETOSTRICTION EFFECT.

This is the way magnetostriction is used in searchlight sonar: Several hundred nickel tubes, each about the diameter of a lead pencil, are mounted in one side of a transducer diaphragm. Each tube is wrapped with a coil of wire. When a direct current is passed through the coil,

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a magnetic field is produced and the tube shortens. When an alternating current is laid over this direct current, the tube shortens and lengthens as the current alternates. Because hundreds of tubes are embedded in the steel diaphragm, the diaphragm vibrates with the action of the alternating current. If the alternating current has a frequency of 20 kcs, the diaphragm vibrates at 20,000 cycles per second and a sound wave of that frequency goes out into the water.

Azimuth search sonar transducers are also magnetostrictive. Instead of nickel tubes, elements of the azimuth transducer have nickel laminations pressed in thermoplastic. Each element contains a 2⅝ inch stack of 0.010-inch laminations. These are shown in the exploded view of a transducer element (one of 48 in a typical transducer) in figure 6–6. A permanent magnet, also shown, provides flux for polarizing the nickel.

Piezoelectricity

Piezoelectricity works in the same manner as magnetostriction except that crystals are used instead of nickel tubes or laminations. These crystals can be either ADP, quartz, tourmaline, or Rochelle salt, but the ADP crystals are used more often than the others.

If the crystals have mechanical pressure applied to them, such as the pressure of an incoming sound wave, they will change their size and produce a small electrical current. On the other hand, if an electric current is passed through the crystals, such as the current from the transmitter, they will change their physical size and produce mechanical energy. In both cases the result is piezoelectrical effect.

This is the way it is put to use in sonar: A number of crystals, cut to a small size, are stacked together to form the diaphragm of the transducer. They are connected electrically to give the effect of one large crystal. When an electric current of desired frequency is passed through

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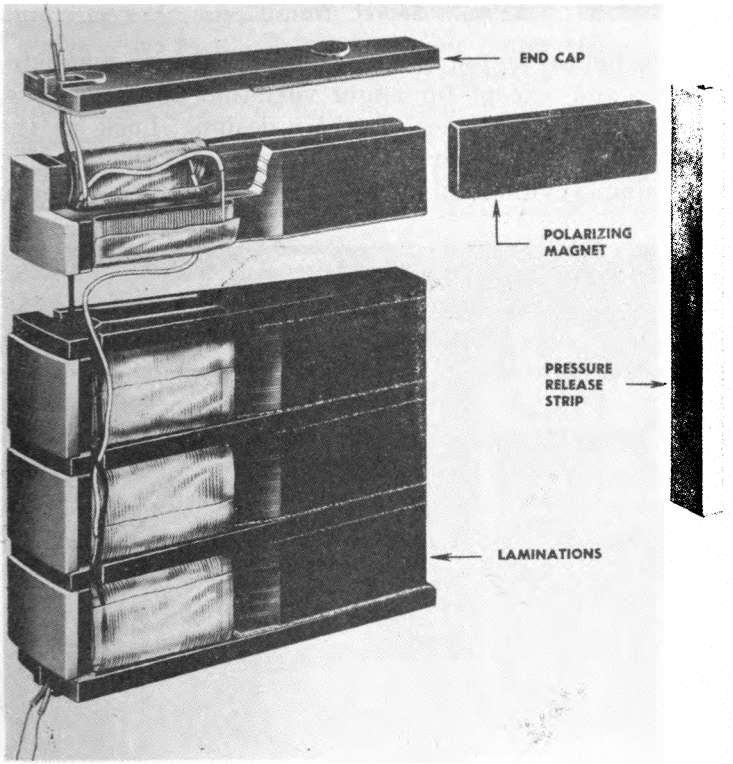

Figure 6–6.—Exploded view of azimuth search sonar transducer stave.

them, they change their size as a unit, thus causing a vibration. Also, when outside energy is received, it exerts mechanical pressure on the crystals, and that pressure produces an electrical current which can be amplified. This type of transducer has no single resonant frequency, as does the magnetostriction transducer. It will operate well over a band of several frequencies.

ADP crystals are used in one type of depth-determining sonar (model QDA) and in the AN/UQN–1B fathometer. Model QJB searchlight sonar also has a crystal transducer.

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Azimuth Search Transducers

All azimuth search sonar transducers are magnetostrictive and, except for slight variation in dimensions, there is little difference in their design. Look at the AN/SQS–11 transducer shown in figure 6–7. Externally, it is a simple cylindrical object approximately 19 inches in

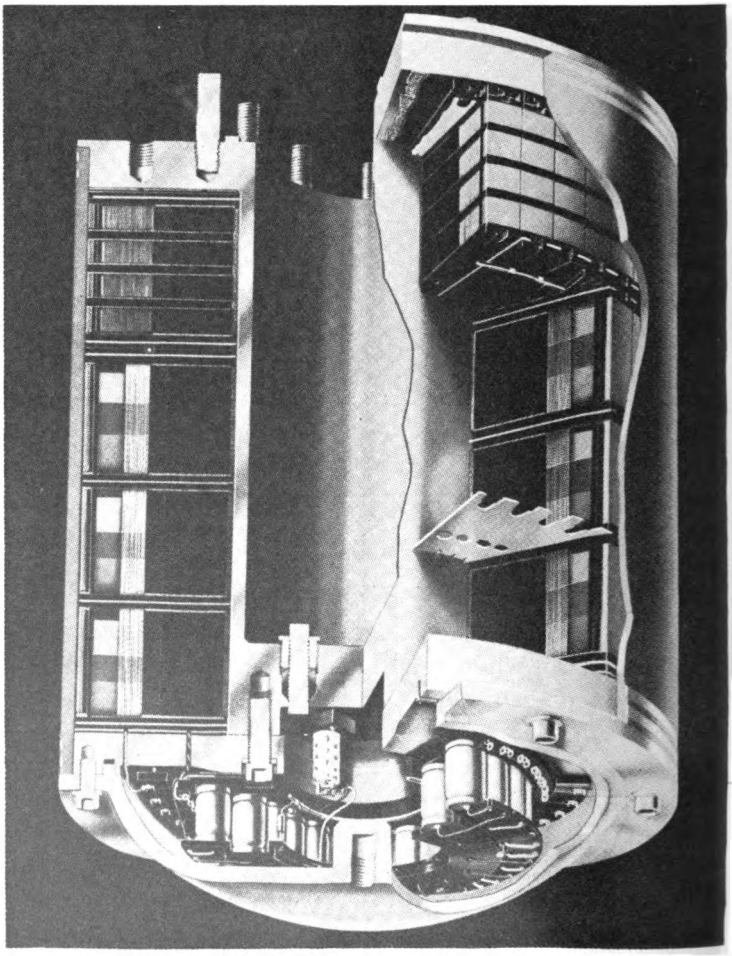

Figure 6–7.—AN/SQS–11 transducer.

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diameter with a maximum over-all length of 26.88 inches. Twelve studs secure it to a mounting flange and a circular key provides the necessary water seal to the interior of the transducer shaft. The top and bottom surfaces are stainless steel castings with lifting bolt holes in both ends. The surface between is a heavy rubber jacket, or "boot," over the active elements. Two stainless steel bands at each end of the rubber jacket secure it in place and help provide a water seal for the interior of the transducer.

Electrically, this unit is actually two independent transducers in a common housing. The SEARCH section is made up of 48 vertical staves or microphone elements, each having an active length of 12.67 inches and a width of approximately 1.18 inches. Each element contains nickel laminations and a polarizing magnet, and each is electrically independent of the others. In AN/SQS–11 and QHBa, the elements are divided internally into three sections; in AN/SQS–10 they are divided into four sections.

Located directly above this array of microphone elements is a second ring of staves, each of which is approximately 4⅛ inches high. This ring of staves is the second transducer within the common housing. These elements are used for echo ranging when you have a deep target or when the target is close and the ship is approaching to pass over it. Each element is divided into four sections (see fig. 6–7), connected and phased to transmit sound downward at an angle of approximately 30°. Because it permits you to hold contact with a target until the last moment, this transducer within a transducer is called maintenance of close contact (MCC). You select normal or MCC operation at the sonar console, as directed by your supervisor.

There is no need to rotate the transducer of azimuth search sonar since the 48 microphone elements cover 360°. When you train the audio system to the bearing of the target you are simply cutting in the microphones on which the returning echo is loudest. Actual selection takes place

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in the scanning switch assembly in the sonar equipmen room.

Transducer Transfer Switch

When you select the normal search or MCC portions of the transducer, the connection is made through the transducer transfer switch. This switch, as you can see in figure 6–1, is located near the transducer. The top cover is fitted with a small window through which a dial indicates whether the system is using normal search or MCC.

AF-RF or RF AMPLIFIER

The AF-RF or RF amplifier is primarily concerned with preamplification of the 48 signals from the transducer (AF-RF in SQS–10; RF in AN/SQS–11). In addition, the unit contains the keying relay and the transducer tuning inductor and capacitors. It contains the following assemblies: cabinet, preamplifiers, power supply chassis, and capacitor panel.

Two preamplifier chassis are mounted in the upper and lower front portion of the cabinet, as shown in figure 6–8. When the top chassis is hinged out, it provides access to a number of terminal boards, the blower assembly, and the upper portion of the transmitter tuning capacitors. Hinging out the lower chassis gives access to the remaining terminal boards, the tuning inductor, and the remaining transmitter tuning capacitors.

The power supply is mounted vertically along the rear lower wall of the cabinet. To the right are 48 transmitter tuning capacitors and the tuning inductor. The main terminal board is at the center of the back wall and subordinate terminal boards are located above and on the side walls. Transducer cable and cables connecting other units enter directly above the main terminal board. An exhaust fan, mounted at the upper rear of the cabinet, provides forced ventilation.

Electrical wiring of the cabinet assembly is fairly simple. The transducer terminal board on the rear wall is

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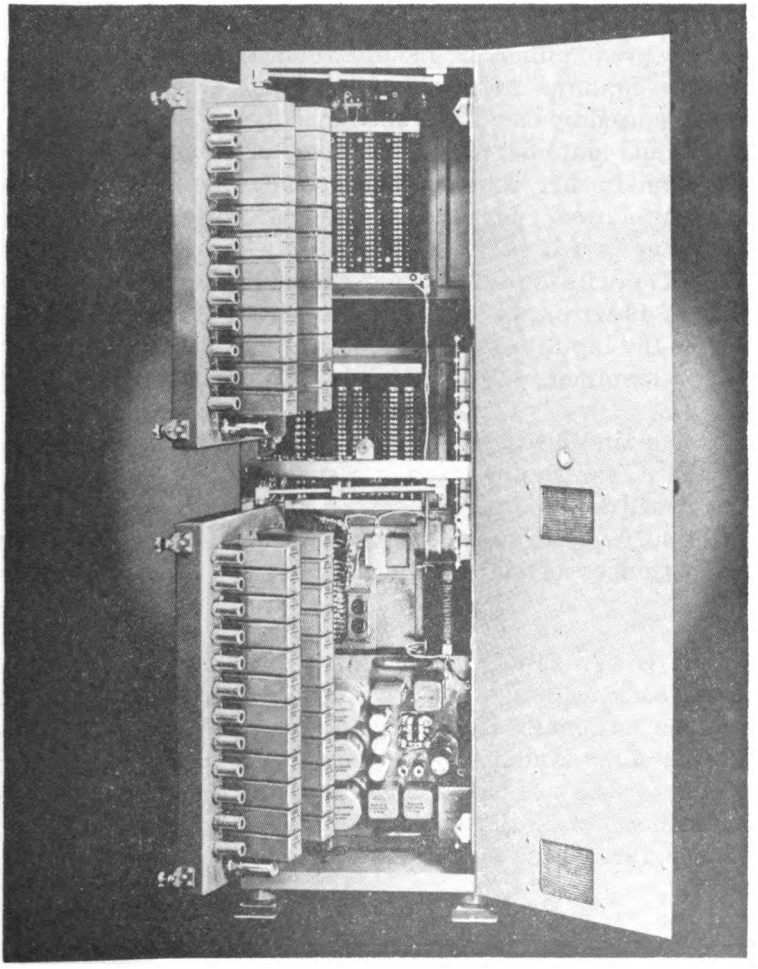

Figure 6–8.—AF-RF amplifier.

connected by 48 twisted pairs to two terminal boards (24 pairs to each board), and to the two preamplifier chassis. Output of the preamplifier is connected to the main terminal board, thence to the receiver-scanning switch assembly. Directly above the power supply there is a convenience outlet for test instruments.

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Preamplifier

The preamplifier is mounted on two chassis. Each chassis contains 24 identical amplifier stages and each stage is used by one of the 48 signals from the transducer. Individual amplifier stages are made up of an untuned input transformer coupled to a triode (one-half 12AX7) section followed by a 3-section filter network. Output from the filter is fed into a 2-stage cascade triode amplifier (12AX7) with an untuned transformer for output coupling. A 49-wire cable connects the output of the preamplifier to the input of the scanning switch—48 leads for the 48 preamplifier outputs and one common lead for all stages.

Anode and heater power for both chassis is furnished by the power supply chassis. Each amplifier chassis can be opened and locked in position for maintenance or inspection. You can replace components simply by removing the bottom cover plates for access.

Power Supply Chassis

The power supply is mounted vertically against the lower back wall of the cabinet. The power supply circuit is a conventional full-wave rectifier type with a capacitor-reactor filter system. In addition to the supplying anode power for the two preamplifier chassis, it also powers the operating coil of the keying relay. A regulated 150-volt source for the receiver chassis also comes from this supply.

Capacitor Panel

The capacitor panel is a flat metal plate with 48 capacitors fastened to it. The entire assembly can be removed as a unit, once the lead connections and mounting screws are removed.

RECEIVER-SCANNING SWITCH ASSEMBLY

The receiver-scanning switch assembly forms acoustic beams from the 48 preamplified transducer signals and

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amplifies signals from the two scanning switches to operate the video and audio indicators of the system. It includes the following assemblies: cabinet, audio scanning switch, video scanning switch, 3-channel receiver, and power supply. These can be seen in figure 6–9.

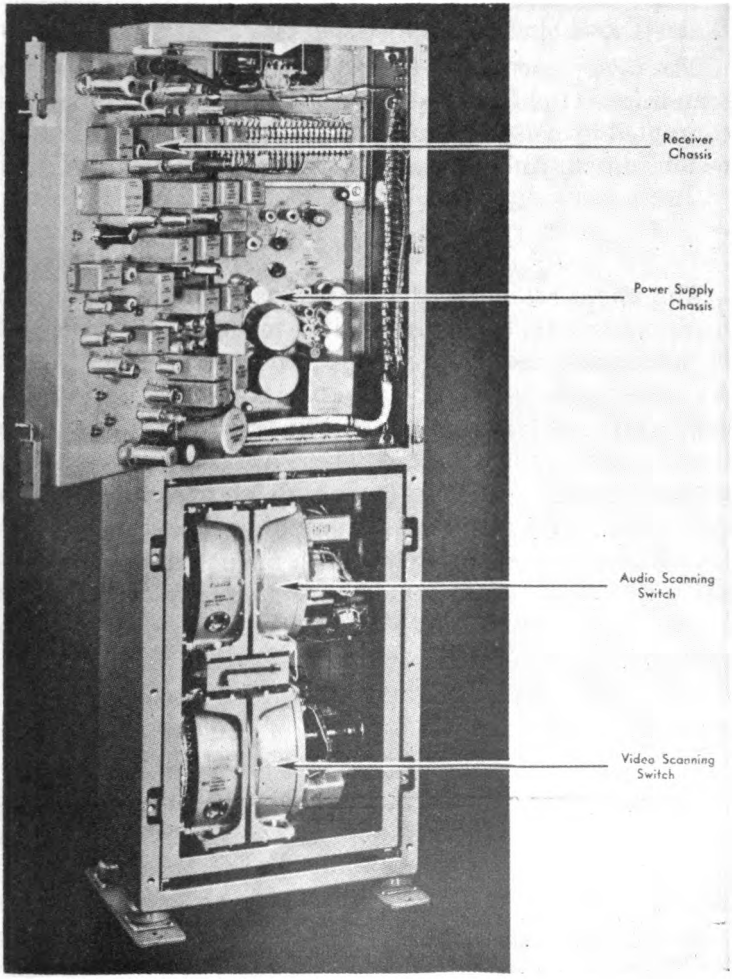

Figure 6–9.—Receiver scanning switch assembly.

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The 3-channel receiver is mounted in the upper portion of the cabinet where it is hinged vertically to the left side. Power supply is hinged horizontally at the bottom of the upper portion of the cabinet. To the left of the power supply is the main terminal board, and directly above the power supply is the terminal board used for connections to other cabinets of the equipment. A forced blower ventilates the cabinet.

The lower portion of the cabinet contains only the two scanning switches. The preamplifier terminal board is connected by a 49-wire cable to the upper scanning switch, which in turn connects to the lower scanning switch.

Audio Scanning Switch

The audio scanning switch is located above the video scanning switch. Structurally, it is made of two large cast iron cups doweled and bolted together at their open ends. At one end (left end as you see it in figure 6–9) is a circular terminal board to which the 48 output leads of the preamplifiers are connected. These are connected directly by short conducting loops to pins which protrude through the left-hand surface of the scanning switch proper. This cup-shaped casting also contains a mica and glass composition (Mykroy) disk, coated with aluminum and scribed with 48 radial divisions. Each division or segment has a connecting pin to provide a complete circuit from the segment to a preamplifier. The preamplifier, of course, is connected to one of the 48 elements of the transducer. The scribed Mykroy disk forms a stator—it does not move.

The scanning switch rotor is located in the right cup-shaped casting, as indicated in figure 6–9. A Mykroy disk with a metal backing plate—identical to the stator plate assembly—is bolted to a large steel hub shrunk on the rotor shaft. An air gap of 0.0035 to 0.0040 exists between the stator and rotor plates. With the segments of the two plates lined up, 48 capacitors of 80 mmf to 100 mmf are

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formed. These provide capacitive coupling for the outputs of 48 preamplifiers to the electrical network carried by the rotor assembly. At any given bearing, the rotor accepts the preamplified output of 16 transducer staves (SQS–10 and –11 equipment) or 18 transducer staves (QHBa equipment) to form an acoustic beam. The electrical energy, which started as an acoustic beam, passes through sliprings to be picked up by brushes and sent to the receiver for further amplification.

The audio scanning switch rotor can be trained to any angle by a synchro training order. When you change the bearing of the audio cursor with the training control knob, you are changing the angle of the audio scanning switch rotor.

Video Scanning Switch

In the QHBa and sonar sets of the AN/SQS–10 and –11 series, the video scanning switch is almost identical to the audio scanning switch, except for the rotor driving system and the number of segments. Instead of a servo drive, the rotor in the QHBa is driven continuously by a 3500-rpm, 1/20-horsepower capacitor start-run induction motor. In AN/SQS–10 and –11 equipment, the rotor is driven continuously by two such motors. In QHBa sets, both audio and video scanning switches have 48 segments, but in AN/SQS–10 and –11 sets, both rotor and stator plates are divided into 144 segments to form three complete sectors of 48 segments each.

In the video scanning switch of the AN/SQS–10 and –11 series, each segment in the rotor and stator is connected to corresponding segments in the other two sectors. The amplified signal from transducer stave No. 1 is connected to stator segment No. 1, stator segment No. 49, and stator segment No. 97. The signal from transducer stave No. 2 is connected to stator segment No. 2, segment No. 50, and segment No. 98, and so on. This can be seen

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in the video scanning switch circuit in figure 6–10. The result is three complete scanning cycles with each revolution of the rotor. Only one scanning cycle per rotor revolution is possible with the QHBa video scanning switch. The speed of the motor driving the QHBa rotor is reduced by helical gears 2 to 1, producing a speed of 1750 rpm. Helical gears reduce motor speed in AN/SQS–10 and –11 sets to about 3000 rpm, or 150 scanning cycles per second.

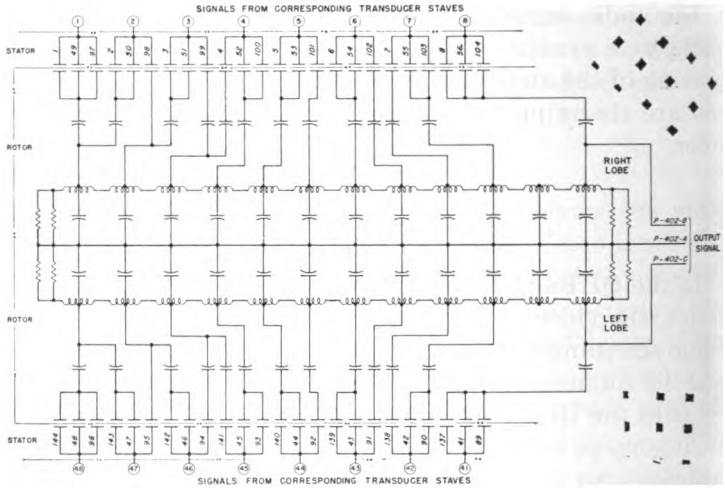

Figure 6–10.—Video scanning switch circuit.

A 3-phase ac-voltage, modified by circuits which correct for ship's heading and errors caused by pitch and roll, is induced in the stator windings of the video scanning switch assembly. This voltage is connected to the deflection coils of the cathode-ray tube in the control indicator where it synchronizes the beam of the tube IN ANGLE with the true bearing of the video channel beam pattern, and IN RADIUS with range. Output of the video scanning switch rotor is connected, through amplifiers, to the grid of the cathode-ray tube of sonarscope to produce a pip indicating the range and bearing of the echo.

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SONAR RECEIVER

The sonar receiver is located in the upper half of the cabinet housing the scanning switch assembly. It is a 3-channel receiver containing one listening and two video channels which amplify signals from directional sensitivity circuits as required by audio and visual indicators. The receiver operates on a fixed frequency of 20 kcs (AN/SQS–10, –10A) and 25.5 kcs (AN/SQS–11, –11A).

The video portion of the receiver uses a left and right channel to accept the two lobes of a signal from the video scanning switch. As you have already learned, the output from 16 consecutive transducer staves is used in SQS–10 and –11 equipment to form the beam pattern. Each lobe represents the output from 8 consecutive staves, or the right and left halves of the 16–stave group. (See again fig. 6–10.) Output signals from the two receiver channels are combined, in two modes of operation, to produce a brightening voltage on the cathode-ray scope. In the SUM mode, left and right channels are combined to give a broad, effective beam pattern. In the DIFFERENCE mode, the signals are combined to form an extremely sharp pattern.

The receiver audio channel uses a simple superheterodyne circuit with a beat frequency oscillator providing an audible signal, as shown in the receiver block diagram, figure 6–11. Frequency of the BFO can be varied by manually controlling own doppler nullifier (ODN) circuit. Ship's speed is set with the manual ODN knob on the control indicator, and the effect of own ship's speed on echo tone is removed. Any change in pitch will then be true doppler, indicating target movement.

SIGNAL DATA CONVERTER

Early models of azimuth search sonars provided target bearings RELATIVE TO THE SHIP'S BOW only, but as underwater fire control systems increased in complexity, it became impractical to work with sonar target relative bear-

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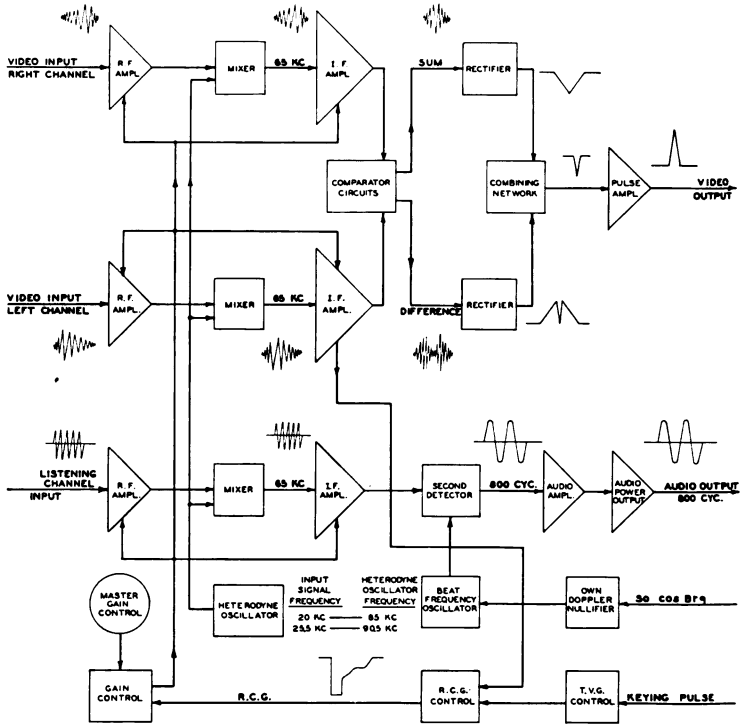

Figure 6–11.—Receiver block diagram.

ings. To correct the situation, the signal data converter was introduced into the sonar system. (See fig. 6–12.) This instrument first appeared in model QHBa, and later in sets of the AN/SQS–10 and –11 series. Its primary job is to convert video presentation to true bearings, stabilized in the horizontal plane. With stabilization, the position of the echo pip on the scope is not affected by ship's roll and pitch.

Because the data converter orients the picture to true north, some means of locating the ship's bow with reference to the sonar picture is necessary. The signal data converter provides for this by generating the stern line indicator, which figured into your studies of bearings and motion earlier in the book.

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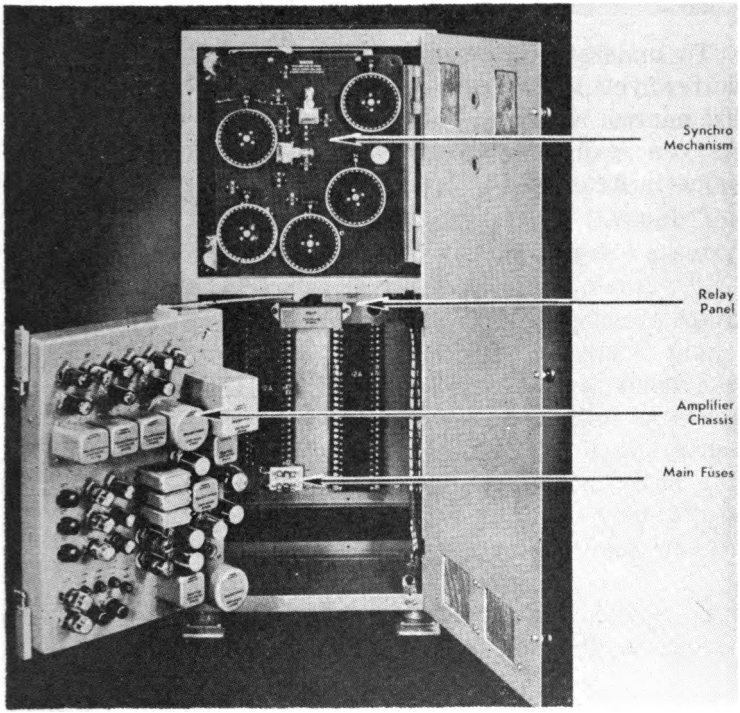

Figure 6–12.—Signal data converter.

There are other functions performed by the signal data converter. When underwater attack directors were perfected, it was possible to generate values that automatically keep the sonar cursor trained on target as the attack develops. (The sonar operator adjusts the cursor in bearing whenever it tends to drift off the pip.) This is called AIDED TRACKING. The signal data converter accepts aided tracking orders from the director and converts these orders to a form that can be used by the sonar control indicator.

The signal data converter also provides true sonar bearings and relative sonar bearings for remote indication.

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Fire Control Symbols

To understand the operation of the signal data converter, you need to know the meaning of certain basic fire control symbols. These are listed and defined below. As you read the explanation of each symbol, check its value in figure 6–13.

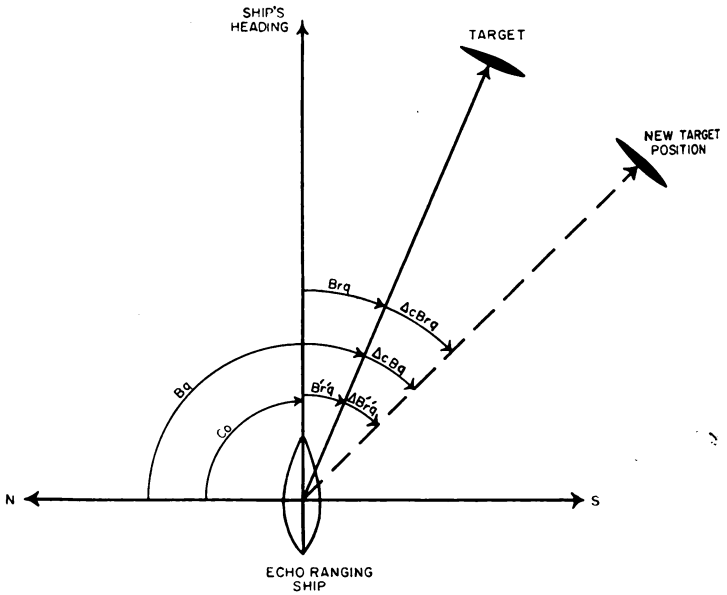

Figure 6–13.—Fire control symbols.

Prefixed to some of the symbols below you will find *c*, and the Greek letter △ (delta). These are called quantity modifiers. When △ appears before a symbol (or quantity) it means a change in, or increment of, that quantity. As a quantity modifier, the letter *c* means that the quantity is not an observed value, but is generated by the equipment. Thus, relative sonar bearing is a quantity carrying the symbol *Brq*. When *Brq* is generated by an attack director, rather than observed by the sonar equipment, it carries the symbol *cBrq*. Increments, or units, of generated relative sonar bearing are indicated by △*cBrq*.

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SYMBOL	MEANING
Bq	Sonar target true bearing. This is the angle from true north through the line of sight to the sonar target, measured clockwise in the horizontal plane.
Brq	Sonar target relative bearing. This is the angle from the ship's bow through the line of sight to the sonar target measured clockwise in the horizontal plane.
B'r'q	Azimuth sonar train. This is relative sonar bearing measured in the DECK plane, rather than in the horizontal plane. In other words, it is the relative sonar bearing you would receive if the sonar equipment was not stabilized. Roll and pitch of the ship would cause the pip to move on the scope even if there was no target motion.
Co	Own ship's course. The angle between true north and ship's bow, normally measured by the gyrocompass.
$\triangle cBrq$	Incremental computed sonar target relative bearing. Change in sonar target relative bearing generated by the attack director. This is the RELATIVE bearing aided tracking order.
$\triangle cBq$	Incremental computed sonar target TRUE bearing. Change in sonar target true bearing obtained by converting the $\triangle cBrq$ order from the attack director. This is the TRUE bearing aided tracking order.
$\triangle B'r'q$	Increment of azimuth sonar train. Angular difference between azimuth sonar train and sonar target relative bearing.

The components in the signal data converter are a relay panel, capacitor mount, synchro mechanism, and ampli-

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fier chassis. In figure 6–14 you see the synchro mechanism dials in the upper portion of the cabinet, and the amplifier in the lower portion. Swinging out the synchro mechanism allows access to the capacitor mount on the rear wall. The mount holds ten synchro phasing capacitors and a terminal board. Three relays are mounted on the cabinet rear wall: (1) gyro circuit transfer relay, (2) stabilization power transfer relay, and (3) gyro and director single-phase power disconnect relay. Additional

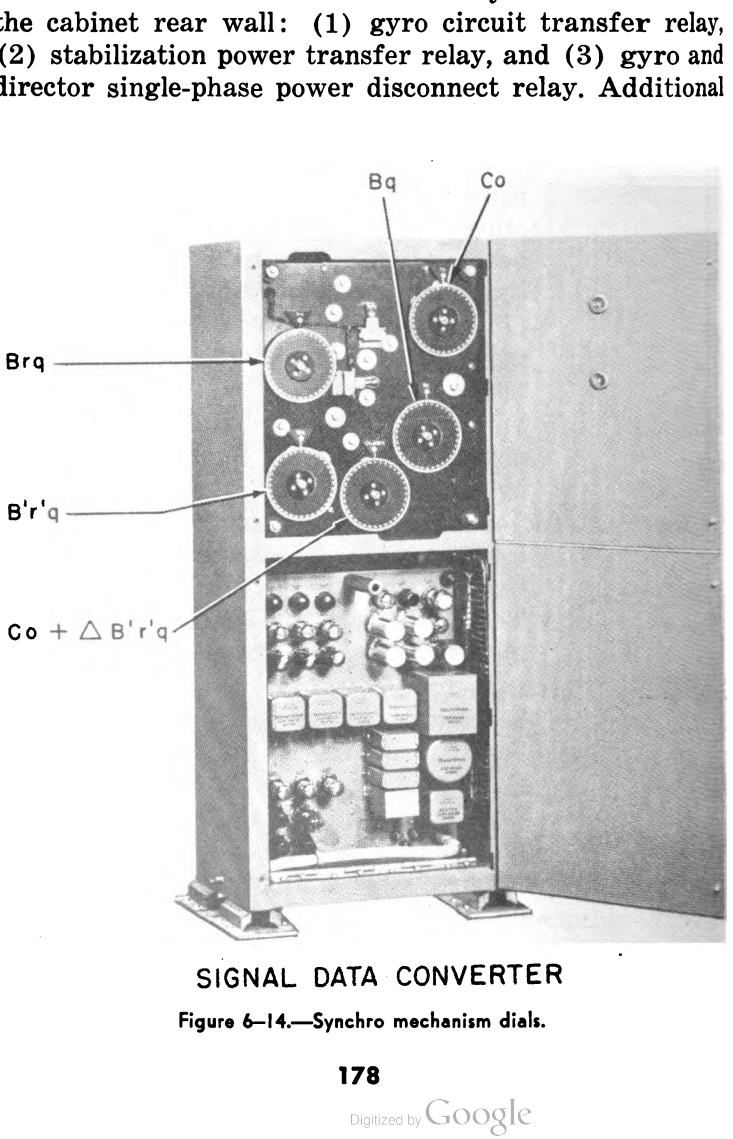

Figure 6–14.—Synchro mechanism dials.

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relays are located directly below the capacitor assembly. Swinging out the amplifier chassis allows access to the main terminal board.

Synchro Mechanism

The synchro mechanism contains the various motors and synchros (and associated gearing) of the signal data converter. On the outside plate, five dials indicate *Brq* (relative sonar bearing), *B'r'q* (azimuth sonar train), *Co*+ $\triangle B'r'q$ (own ship's course plus increments of sonar train), *Bq* (true sonar bearing), and *Co* (own ship's course). The dial positions are shown in figure 6–14. Two pilot lights on the plate indicate, when lighted, power to the unit and absence of gyro excitation.

Before tracing the functions of the synchros, study the synchro block diagram in figure 6–15. Be sure you are completely familiar with the legend identifying servomotors, mechanical differentials, synchro orders, and so forth. As each function is explained, trace it out in the block diagram. (A review of chapter 17, Synchros and Servo Mechanisms, in *Basic Electricity*, NavPers 10086, would be helpful.)

A pair of 1CT synchros accepts relative sonar bearing (*Brq*) order from the sonar console and, by means of a servomotor, drives one face wheel of a differential gear. Two 5G synchros also are driven by the motor, providing transmission of *Brq* to other circuits at 1 and 36 speed.

The other face wheel of the differential gear is driven by a servomotor controlled by two 1CT synchros. These synchros accept own ship's course (*Co*) from the gyro amplifier. The output, true sonar bearing (*Bq*), from the planetary wheel of this differential gear drives a 5G synchro for transmission of a 1-speed *Bq* signal to a true bearing repeater. Output of the differential gear also drives the planetary wheel of a second differential gear. One face wheel of this second differential gear is driven by a servomotor controlled by 1CT synchros which accept

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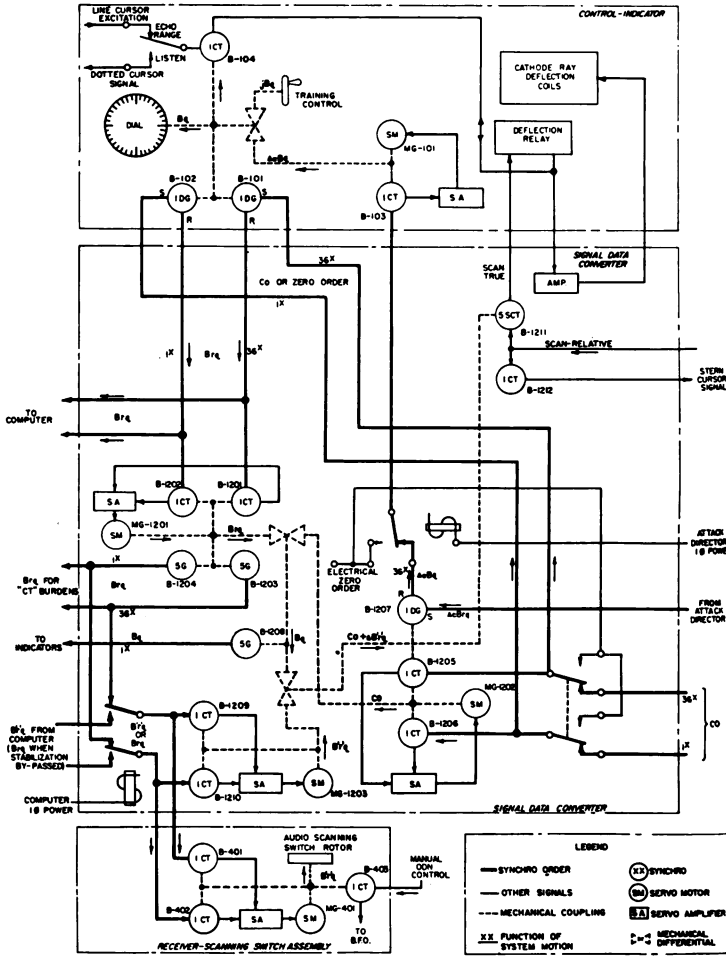

Figure 6–15.—Synchro block diagram.

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an azimuth sonar train ($B'r'q$) order from the stabilization computer.

The output ($Co+ \triangle B'r'q$) from the other face wheel of the second differential gear drives the rotor of a 5SCT. Input to this synchro is the scan signal, relative in the deck plane, generated by the sweep generator on the video scanning switch. Output is a stabilized, true bearing scan signal used by the cathode-ray tube deflection circuits.

The *Co* servomotor, mentioned above, also drives the rotor of a 1DG at 36 speed. Input to the stator is an increment of computed relative bearing ($\triangle cBrq$) signal at 36 speed received from the attack director. Output of this synchro is a 36-speed increment of true sonar bearing ($\triangle cBq$) signal which goes to the aided tracking circuits of the control indicator.

Also located in the synchro mechanism is a 1CT synchro used as a phase shifter. The stator of this synchro is excited by the scan signal from the sweep generator. Rotor output is used to trigger a circuit in the signal data converter amplifier chassis to generate the stern line indicator.

Amplifier Chassis

Components of the following circuits are included in the signal data converter amplifier chassis: three servo amplifiers, the 3-phase sweep signal amplifier, stern indicator circuit, power supplies for all these, and a relay required in transferring gyro single-phase power. Three locking-type potentiometers mounted on the chassis are used to calibrate the 3-phase sweep amplifier.

SONAR TRANSMITTER

The sonar transmitter contains the intermediate and power amplifiers, which supply power output for the transducer when echo ranging. It also contains other power supplies, such as high-voltage, screen, and bias

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supplies, and provides control of transmitter output level. As shown in figure 6–16, there are four decks above the storage capacitors.

TRANSMITTER RACK.—The rack contains all components for the intermediate and power amplifier, and most of the components for various power supplies associated with the transmitter. A series of interlocking plugs and jacks break various circuits when the rack is opened.

INTERMEDIATE AND POWER AMPLIFIER.—This portion of the transmitter contains the intermediate amplifier and associated components, and five paralleled power ampli-

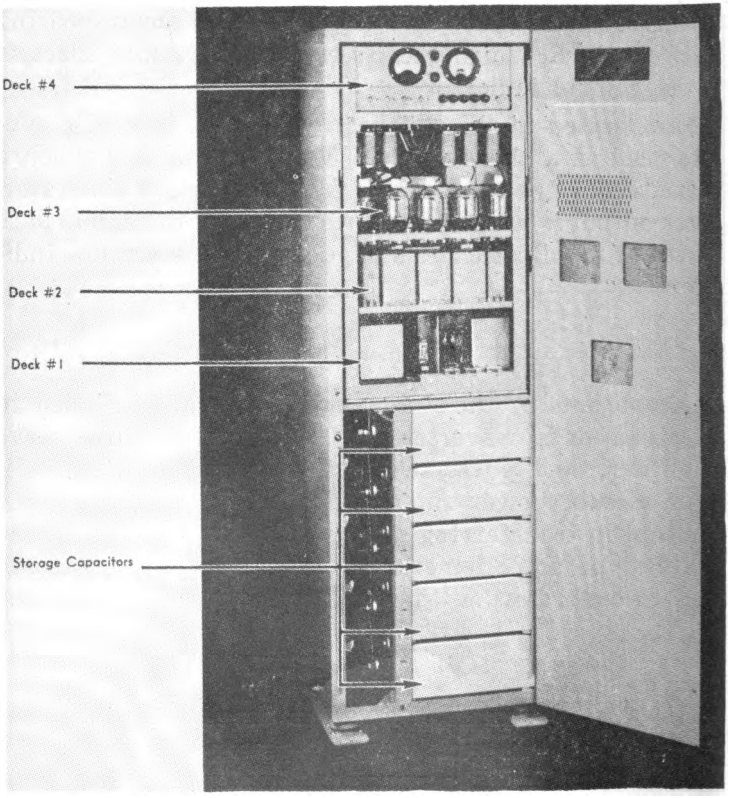

Figure 6–16.—Sonar transmitter.

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fier tubes. Beam power tubes, type 715C or 4PR60A, are used in both stages. Special high-wattage resistors are inserted in each of the five power amplifier tubes to prevent damage in case of flash arcs in the tubes.

The intermediate and power amplifier amplifies the relatively high-impedance pulse from the oscillator and buffer stage in the receiver-scanning switch assembly to the power level required for transmission. For AN/SQS–10 and –11, peak power at normal transmission level, using short pulse length, is approximately 50 kilowatts; for medium pulse, 10 kilowatts; and for long pulse length, 2 kilowatts. Peak power level, using medium and long pulse length, in AN/SQS–10A is approximately 30 kilowatts; for AN/SQS–11A it is 4 kilowatts.

HIGH-VOLTAGE SUPPLY.—This unit charges the storage capacitors during the interval following the echo-ranging pulse. Voltage supplied is approximately 8000 volts when no keying pulse takes place, and 7700 volts at the instant a pulse starts during a keying period.

The supply consists of a large power transformer with primary series-connected with two reactors for low power output, and parallel-connected to the current-limiting reactors for maximum output. The secondary of the high-voltage transformer supplies the anodes of two type 577 rectifier tubes in a full-wave circuit. Heaters of the high-voltage rectifiers are connected directly to the heater transformer, with one connection made directly to the high potential side of the storage capacitors to serve as a bleeder. To indicate the voltage supplied to the power amplifier anodes, a portion of the bleeder combination is paralleled by a kilovoltmeter. A thermal delay relay in the primary circuit allows high-voltage rectifier heaters to reach proper operating temperature before high potential is applied.

SCREEN AND BIAS SUPPLY.—The second deck contains the amplifier screen and bias supplies with associated components. Anode supply for the intermediate amplifier

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also is located here. The deck contains filter capacitors, the transformer, and two 5R4GY rectifiers.

CONTROL AND CALIBRATION.—The top deck contains a number of relays, potentiometers, and other components used in transmitter control circuits. A small front door permits access to screwdriver adjustments and fuses.

There are two indicators: POWER and XMTR THERMAL LIMIT. When lighted, the first indicates power to the transmitter; the second indicates operation on reduced power only. To the left of the indicators, a kilovoltmeter indicates anode voltage to the power amplifier tubes, and further to the left, a running time meter indicates actual number of hours the unit is in operation.

CONTROL INDICATOR

The control indicator is the operator's station and contains all necessary operating controls. This unit, in effect, is a junction box for the entire equipment.

A small control panel, located at the top of the control indicator front panel, contains the following controls and indicators (verify location of controls in fig. 6–17): At the left side is a MANUAL ODN control, which nullifies own ship's doppler effect on the returning echo. To its right is a LOCAL AUDIO control for setting the audio output level. To the right of this control is the VIDEO SUM-DIFF control, with which you already are acquainted. Next in line is a 3-position switch labeled MCC-REDUCED POWER-NORMAL. With it you can select the transmitter power output level as well as the MCC or normal search portion of the transducer. The panel also contains a STABILIZATION ON-OFF switch and the equipment main power switch, labeled POWER ON-OFF.

Front Control Panel

The master gain control for all channels of the receiver is located at the lower left on the front control panel. Directly above the gain control is the SELECTOR switch, providing settings for LISTEN, 1000, 3000, and 6000 yards

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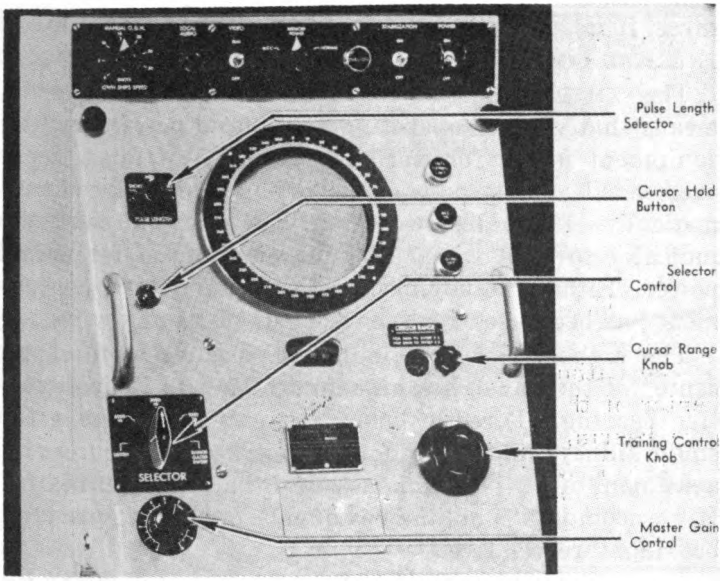

Figure 6–17.—AN/SQS–10 and –11 sonar console showing operator's controls.

echo ranging, and RANGE GATED SWEEP. Above the keying selector switch is the cursor hold button which, when depressed, causes the cursor to appear on the screen.

AN/SQS–10 and –11 series equipments provide pulse lengths of 6, 30, and 80 milliseconds duration, producing short, medium, and long pulse lengths. Selection is made from a 3-position switch labeled PULSE LENGTH.

The training control knob is located at the lower right on the front panel. This knob trains the cursor, thus governing the train angle of the audio scanning switch. As you operate the equipment, your right hand normally will rest on the training control knob and your left hand will control the master gain.

Above the train control knob is a dial labeled CURSOR RANGE, calibrated in yards. A knob allows you to adjust the length of the cursor, thus estimating target range without using a range recorder. The panel also contains

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three indicator lamps: GYRO OFF, MCC OFF, and XMTR THERMAL LIMIT.

The XMTR THERMAL LIMIT indicator, when lighted, means that you are operating at reduced power or, if the equipment is set for normal power, the transmitter is overloaded and its power output has been reduced automatically. There are two conditions that will cause this indicator to light when the equipment is set for normal power. Either the keying rate is excessive, or the equipment has been used for long periods of hand keying.

The cathode-ray tube indicator, located in the upper center of the panel, has an azimuth ring to indicate relative bearing. Directly below the cathode-ray tube is a small kidney-shaped window through which you can see a segment of a 7-inch compass card that indicates bearing. If gyrocompass is on, the bearings are true; if gyro is off, bearings are relative.

On the lower right side wall of the control panel is a hand key covered by a rubber diaphragm.

ENERGIZING EQUIPMENT

To energize AN/SQS–10 or –11 equipment, throw the power switch on the sonar console to the ON position. The bearing and range dials on the control panel and the power-indicating lamp on the receiver-scanning switch will light. After approximately 12 seconds, power-indicating lamps in the AF-RF amplifier, signal data converter, and sonar transmitter will light, indicating these units are energized. During the warmup period, the SELECTOR switch should be in LISTEN. In approximately 30 seconds you will get audio response, in approximately 60 seconds you will get video presentation, and in 270 seconds (4½ minutes) you can commence echo ranging.

If the remote azimuth-range indicator local power switch is on, one of its pilot lamps will come on approximately 12 seconds after you throw the power switch on the sonar console. The local power switch is immediately

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behind the front panel of the remote azimuth-range indicator, and permits you to turn off power to this remote unit independently of the sonar console.

Preliminary Adjustments

A clear presentation on the sonarscope is important. The intensity of the cathode-ray tube must be adjusted to suit light conditions in sonar control. Turn the master gain control to zero, lower the console front panel, and adjust the intensity control until the circular sweep trace is just below the threshold of visibility. Depress the cursor hold button, and adjust cursor intensity to a comfortable level of brilliance.

With the front panel still lowered, make certain the GYRO ON-OFF switch, immediately below the cathode-ray tube intensity control, is on. Close the front panel and check that the GYRO OFF pilot light is out. Observe that the ship's head, as indicated by the stern line, agrees with own ship's course reported from the bridge.

Search Settings

For normal search, set up the controls as follows:

CONTROL	POSITION
STABILIZATION	Off
MCC-REDUCED POWER-NORMAL	Normal
VIDEO	Sum
MANUAL ODN	Ship's speed, as reported from bridge
PULSE LENGTH	Medium

If the sonar message indicates an assured range of 2500 yards or less, set the selector switch at 3000 yards. If assured range is greater than 2500 yards, set switch for 6000 yards. Set the master gain control to the point where water noise causes faint and random brightening of the sonarscope. Set the local audio control to a comfortable level or, if your supervisor so instructs, plug in the headphones.

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If an echo pip appears at the same range and bearing for several transmissions, investigate the contact. Train the cursor to the echo, and listen for doppler while you get the range and bearing. Report the contact immediately. If you have difficulty determining doppler, try several transmissions with long pulse length.

If you should be on long scale and suspect a target in close, recycle the equipment with the hand key immediately after the target echo appears. This is important because the equipment transmits only once every 7½ seconds when set for 6000-yard sweep.

The equipment may occasionally be used in LISTEN, but it should never be set for this mode of operation without the express permission of your supervisor.

Tracking

Once contact is established and you commence tracking, equipment controls should be changed as follows:

CONTROL	POSITION
VIDEO	Difference
PULSE LENGTH	Short
MANUAL ODN	Latest report of ship's speed

Keep the stabilization switch off and the transmission switch in normal when you begin tracking the target.

As you track, keep the selector switch at the fastest sweep rate that keeps the echo on the screen. Operate the gain control for the best echo resolution, but be careful not to use a gain setting so high that it defocuses the picture. Immediately after the echo appears on the screen, depress the cursor hold button and adjust the cursor until it exactly bisects the pip. Report bearings continuously, adjusting the length of the cursor to the range. Once the range recorder is cut in, it won't be necessary for you to report range. The recorder will key the equipment.

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If you have no doppler indication, try an occasional transmission on medium pulse.

If contact is lost at short range, the sonar supervisor will order the equipment shifted to MCC. If you still do not regain contact, try medium pulse and sum brightening. When contact is regained, return to difference brightening and short pulse.

In attempting to regain contact after attack, you frequently will find that the target is masked by own ship's wake. If the estimated range to the target is not more than 1000 yards, try MCC. If you do not locate the target in the wake immediately, shift to normal transmission and carry out standard search.

General Comments on Operating Procedures

TARGET ASPECT.—With good sonar conditions, you sometimes can determine target aspect directly from the scope when operating on the 1000-yard scale or in range gated sweep. Some distortion of target aspect can be expected in range gated sweep, but careful attention to the angle of the target with respect to the bearing cursor may reveal target aspect. Report target aspect without delay.

ODN CONTROL.—It is possible the report of ship's speed from the bridge is not accurate. You can check ODN compensation by training directly abeam, transmitting, and then quickly training 45° forward or aft. The pitch of reverberations should not change. If the pitch does change, readjust ODN control until no difference in pitch is noted. Report this to the sonar supervisor.

TRANSMITTER THERMAL LIMIT.—The transmitter is subject to overloading if you hand key for long periods of time, or if you operate in long pulse with the recorder in control. A protective relay in the transmitter automatically reduces power input when this happens, and the XMTR THERMAL LIMIT pilot light comes on. When the indicator lights, stop hand keying or shift to medium or short pulse.

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STABILIZATION.—On a ship equipped with a stabilization computer, stabilization should be turned off until your supervisor instructs you to turn it on. With stabilization ON, it is possible to get erratic behavior of the display. Generally, you will get continuous or erratic rotation of the stern cursor. Turn stabilization off and report to your supervisor.

REDUCED POWER.—This feature can be used to reduce interference between ships in multiple-ship operations. Again, don't set the equipment for reduced power unless doctrine or your supervisor directs. Another way of minimizing intership interference is with the difference brightening setting.

COMMUNICATIONS.—For underwater communications with the hand key, the selector switch must be in the LISTEN position. In this position, a 400-cycle modulation is imposed on the ultrasonic output of the transmitter. With the selector switch in any of the echo-ranging positions, the hand key serves only to initiate a transmission and recycle the cathode-ray tube display.

Further information on underwater communication can be found in chapter 13 of this training course.

AZIMUTH-RANGE INDICATOR

A complete azimuth search sonar set system will include two remote units, called azimuth-range indicators. A unit of this type can be seen in figure 6–18.

Controls on an azimuth-range indicator affect audio and video response of the remote unit, but do not affect operation of the sonar console. For best performance, adjust the cathode-ray intensity to a comfortable level, as you would for the sonar console. Set the signal intensity control to the midpoint, and have another Sonarman set the console master gain control to zero. With these settings, adjust the intensity control of the azimuth-range indicator until the spiral trace is just below threshold visibility. This should be at, or near, maximum setting.

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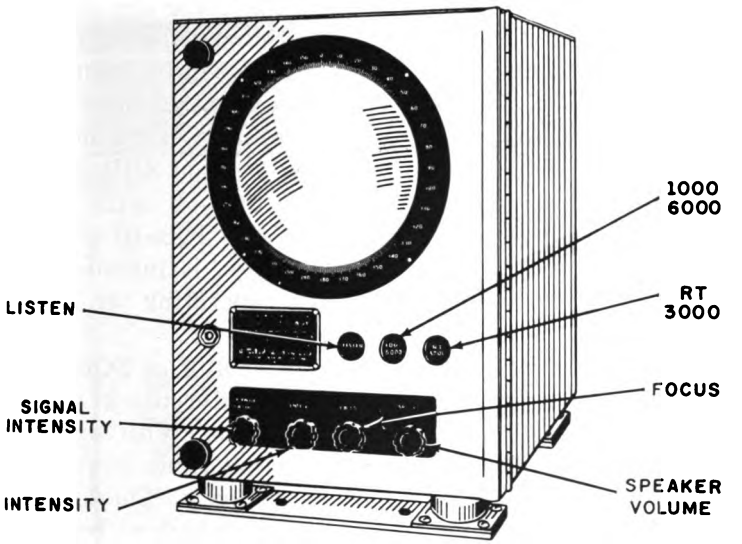

Figure 6–18.—Azimuth-range indicator.

Focus the stern cursor and, with the equipment master gain control in operating position, adjust speaker volume and signal intensity to comfortable levels.

One of three pilot lights will tell you the mode of operation of the console in sonar control. On AN/SQS–10 and –11 sonar sets, these pilots are labeled: LISTEN, 1000–6000, and RT–3000. You can tell whether the equipment is keying on 1000 yards or 6000 yards by the rate of sweep. When the RT–3000 indicator lights, it means a range recorder is keying the equipment or the equipment is keying on 3000 yards. Again, sweep rate will indicate mode of operation.

Pilot lights on the remote azimuth-range indicator of QHBa equipment indicate LISTEN, 3750, and 1500. Otherwise, there is no difference in the remote indicators.

AN/SQR–3 AND –4

Sonar Receiving Sets AN/SQR–3 and –4 are depth-determining equipments intended for use with azimuth

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search sonar sets. Strictly speaking, these are listening equipments capable of indicating the angle of depression of an ultrasonic sound source. They have been called "parasitic" echo-ranging sonars because they use azimuth search sonar transmissions to determine target depth.

The only difference between SQR–3 and SQR–4 is the operating frequency. Model AN/SQR–3, with a frequency of 20 kc, is installed with AN/SQS–10 or –10A; and AN/SQR–4, operating at 25.5 kc, is installed with AN/SQS–11, –11A, or a QHBa operating at exactly 25.5 kc.

Figure 6–19 shows the control indicator of SQR equipment. As you can see, there is little difference in appearance between SQR and SQS consoles. With only one exception, the top panel contains the same controls as AN/SQS–10 and –11 azimuth search sets. The lone difference is the SEARCH ON-OFF switch, which occupies the position of the MCC-REDUCED POWER-NORMAL switch of azimuth search sets.

The search switch is turned on when SQR–3 or –4 is used as an independent echo-ranging sonar (still using azimuth search sonar transmissions). With the switch on, you can search for echo-producing objects directly ahead of the ship, while the azimuth search operator investigates some other bearing.

Three controls on the front panel are familiar from your study of azimuth search equipment: MASTER GAIN, SELECTOR SWITCH, and TRAIN CONTROL. The master gain controls video and audio gain. The selector switch has listen and range gated positions, as do azimuth search sonars, but echo range settings are 750, 1500, and 3000.

Cursors

When SQR equipment is set for echo ranging, a solid line cursor prints each time the equipment cycles. Essentially, this is the same cursor used for bearing indication in azimuth search sonar. In SQR it measures the angle

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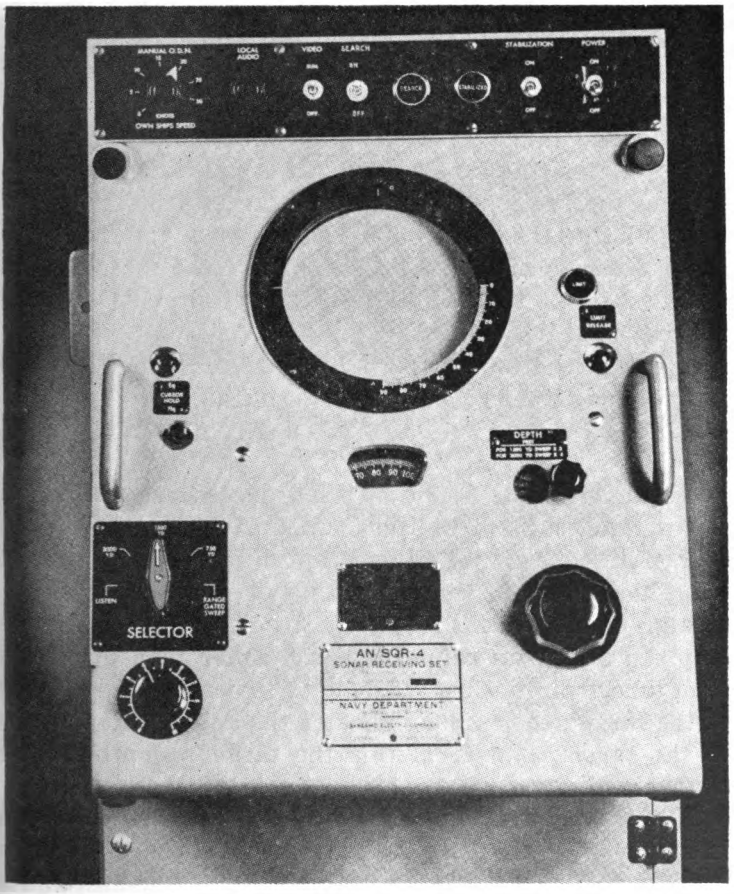

Figure 6–19.—AN/SQR–3 and –4 console, showing operator's controls.

of depression of the sound beam to the target with respect to the ocean surface. It is called the depression angle cursor and carries the symbol *Eq*. The training control knob moves this cursor radially through a calibrated quadrant of 90°, and a small dial under the cathode-ray scope indicates depression angle. One revolution of the training control knob rotates the cursor 20°; it can also be slewed right or left at 8 rpm.

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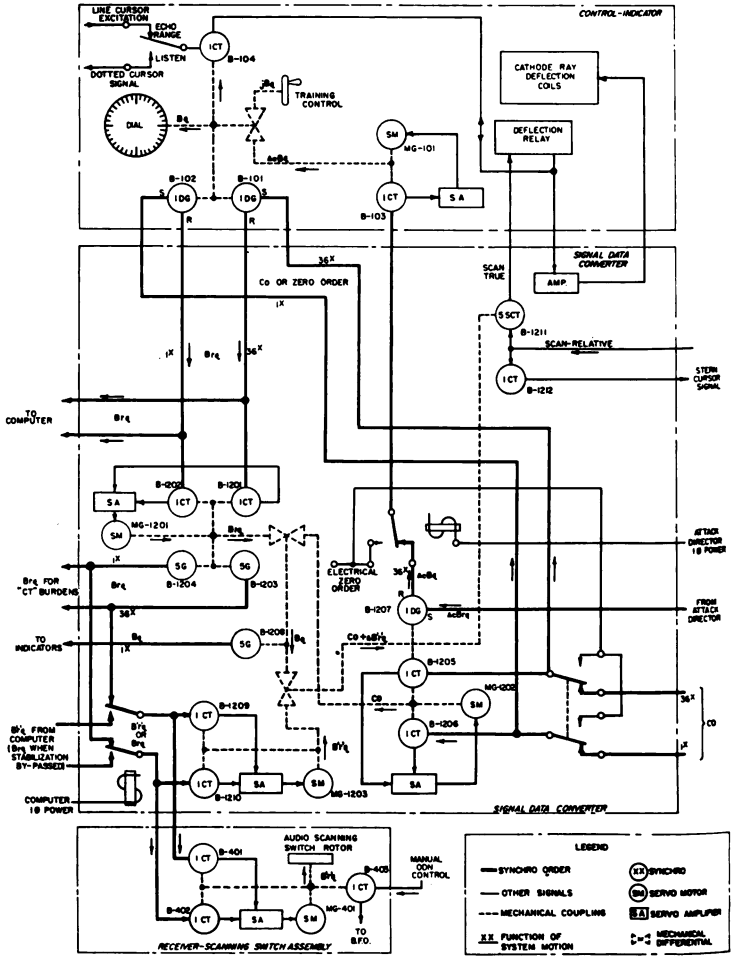

Figure 6–15.—Synchro block diagram.

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an azimuth sonar train ($B'r'q$) order from the stabilization computer.

The output ($Co+ \triangle B'r'q$) from the other face wheel of the second differential gear drives the rotor of a 5SCT. Input to this synchro is the scan signal, relative in the deck plane, generated by the sweep generator on the video scanning switch. Output is a stabilized, true bearing scan signal used by the cathode-ray tube deflection circuits.

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Amplifier Chassis

Components of the following circuits are included in the signal data converter amplifier chassis: three servo amplifiers, the 3-phase sweep signal amplifier, stern indicator circuit, power supplies for all these, and a relay required in transferring gyro single-phase power. Three locking-type potentiometers mounted on the chassis are used to calibrate the 3-phase sweep amplifier.

SONAR TRANSMITTER

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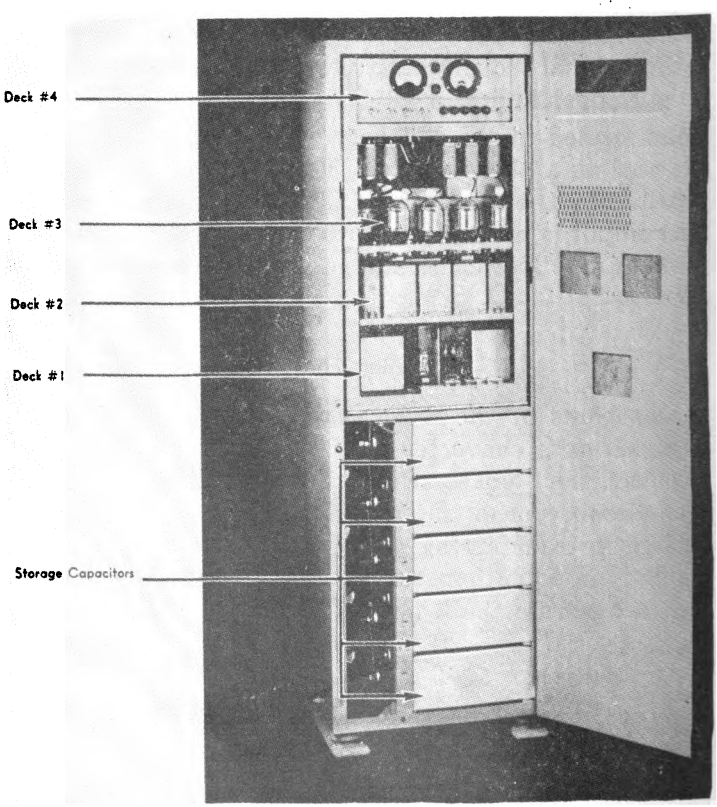

Figure 6–16.—Sonar transmitter.

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fier tubes. Beam power tubes, type 715C or 4PR60A, are used in both stages. Special high-wattage resistors are inserted in each of the five power amplifier tubes to prevent damage in case of flash arcs in the tubes.

The intermediate and power amplifier amplifies the relatively high-impedance pulse from the oscillator and buffer stage in the receiver-scanning switch assembly to the power level required for transmission. For AN/SQS–10 and –11, peak power at normal transmission level, using short pulse length, is approximately 50 kilowatts; for medium pulse, 10 kilowatts; and for long pulse length, 2 kilowatts. Peak power level, using medium and long pulse length, in AN/SQS–10A is approximately 30 kilowatts; for AN/SQS–11A it is 4 kilowatts.

HIGH-VOLTAGE SUPPLY.—This unit charges the storage capacitors during the interval following the echo-ranging pulse. Voltage supplied is approximately 8000 volts when no keying pulse takes place, and 7700 volts at the instant a pulse starts during a keying period.

The supply consists of a large power transformer with primary series-connected with two reactors for low power output, and parallel-connected to the current-limiting reactors for maximum output. The secondary of the high-voltage transformer supplies the anodes of two type 577 rectifier tubes in a full-wave circuit. Heaters of the high-voltage rectifiers are connected directly to the heater transformer, with one connection made directly to the high potential side of the storage capacitors to serve as a bleeder. To indicate the voltage supplied to the power amplifier anodes, a portion of the bleeder combination is paralleled by a kilovoltmeter. A thermal delay relay in the primary circuit allows high-voltage rectifier heaters to reach proper operating temperature before high potential is applied.

SCREEN AND BIAS SUPPLY.—The second deck contains the amplifier screen and bias supplies with associated components. Anode supply for the intermediate amplifier

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also is located here. The deck contains filter capacitors, the transformer, and two 5R4GY rectifiers.

CONTROL AND CALIBRATION.—The top deck contains a number of relays, potentiometers, and other components used in transmitter control circuits. A small front door permits access to screwdriver adjustments and fuses.

There are two indicators: POWER and XMTR THERMAL LIMIT. When lighted, the first indicates power to the transmitter; the second indicates operation on reduced power only. To the left of the indicators, a kilovoltmeter indicates anode voltage to the power amplifier tubes, and further to the left, a running time meter indicates actual number of hours the unit is in operation.

CONTROL INDICATOR

The control indicator is the operator's station and contains all necessary operating controls. This unit, in effect, is a junction box for the entire equipment.

A small control panel, located at the top of the control indicator front panel, contains the following controls and indicators (verify location of controls in fig. 6–17): At the left side is a MANUAL ODN control, which nullifies own ship's doppler effect on the returning echo. To its right is a LOCAL AUDIO control for setting the audio output level. To the right of this control is the VIDEO SUM-DIFF control, with which you already are acquainted. Next in line is a 3-position switch labeled MCC-REDUCED POWER-NORMAL. With it you can select the transmitter power output level as well as the MCC or normal search portion of the transducer. The panel also contains a STABILIZATION ON-OFF switch and the equipment main power switch, labeled POWER ON-OFF.

Front Control Panel

The master gain control for all channels of the receiver is located at the lower left on the front control panel. Directly above the gain control is the SELECTOR switch, providing settings for LISTEN, 1000, 3000, and 6000 yards

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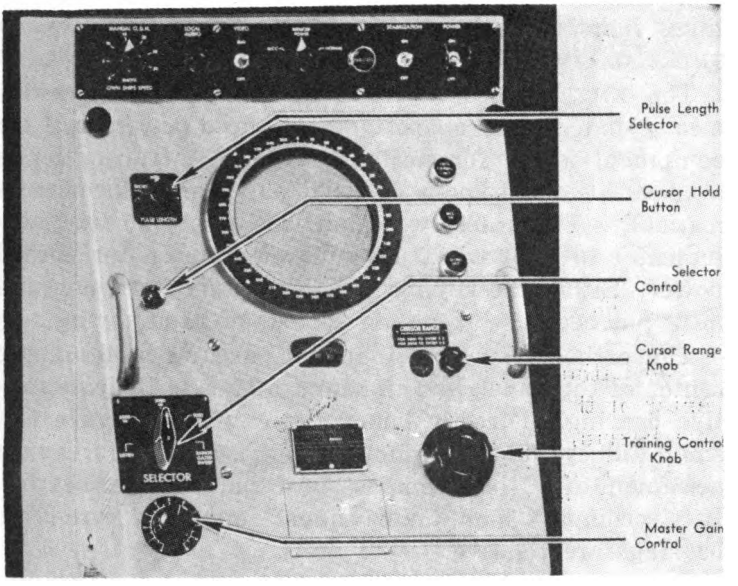

Figure 6–17.—AN/SQS–10 and –11 sonar console showing operator's controls.

echo ranging, and RANGE GATED SWEEP. Above the keying selector switch is the cursor hold button which, when depressed, causes the cursor to appear on the screen.

AN/SQS–10 and –11 series equipments provide pulse lengths of 6, 30, and 80 milliseconds duration, producing short, medium, and long pulse lengths. Selection is made from a 3-position switch labeled PULSE LENGTH.

The training control knob is located at the lower right on the front panel. This knob trains the cursor, thus governing the train angle of the audio scanning switch. As you operate the equipment, your right hand normally will rest on the training control knob and your left hand will control the master gain.

Above the train control knob is a dial labeled CURSOR RANGE, calibrated in yards. A knob allows you to adjust the length of the cursor, thus estimating target range without using a range recorder. The panel also contains

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three indicator lamps: GYRO OFF, MCC OFF, and XMTR THERMAL LIMIT.

The XMTR THERMAL LIMIT indicator, when lighted, means that you are operating at reduced power or, if the equipment is set for normal power, the transmitter is overloaded and its power output has been reduced automatically. There are two conditions that will cause this indicator to light when the equipment is set for normal power. Either the keying rate is excessive, or the equipment has been used for long periods of hand keying.

The cathode-ray tube indicator, located in the upper center of the panel, has an azimuth ring to indicate relative bearing. Directly below the cathode-ray tube is a small kidney-shaped window through which you can see a segment of a 7-inch compass card that indicates bearing. If gyrocompass is on, the bearings are true; if gyro is off, bearings are relative.

On the lower right side wall of the control panel is a hand key covered by a rubber diaphragm.

ENERGIZING EQUIPMENT

To energize AN/SQS–10 or –11 equipment, throw the power switch on the sonar console to the ON position. The bearing and range dials on the control panel and the power-indicating lamp on the receiver-scanning switch will light. After approximately 12 seconds, power-indicating lamps in the AF-RF amplifier, signal data converter, and sonar transmitter will light, indicating these units are energized. During the warmup period, the SELECTOR switch should be in LISTEN. In approximately 30 seconds you will get audio response, in approximately 60 seconds you will get video presentation, and in 270 seconds (4½ minutes) you can commence echo ranging.

If the remote azimuth-range indicator local power switch is on, one of its pilot lamps will come on approximately 12 seconds after you throw the power switch on the sonar console. The local power switch is immediately

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behind the front panel of the remote azimuth-range indicator, and permits you to turn off power to this remote unit independently of the sonar console.

Preliminary Adjustments

A clear presentation on the sonarscope is important. The intensity of the cathode-ray tube must be adjusted to suit light conditions in sonar control. Turn the master gain control to zero, lower the console front panel, and adjust the intensity control until the circular sweep trace is just below the threshold of visibility. Depress the cursor hold button, and adjust cursor intensity to a comfortable level of brilliance.

With the front panel still lowered, make certain the GYRO ON-OFF switch, immediately below the cathode-ray tube intensity control, is on. Close the front panel and check that the GYRO OFF pilot light is out. Observe that the ship's head, as indicated by the stern line, agrees with own ship's course reported from the bridge.

Search Settings

For normal search, set up the controls as follows:

CONTROL	POSITION
STABILIZATION	Off
MCC-REDUCED POWER-NORMAL	Normal
VIDEO	Sum
MANUAL ODN	Ship's speed, as reported from bridge
PULSE LENGTH	Medium

If the sonar message indicates an assured range of 2500 yards or less, set the selector switch at 3000 yards. If assured range is greater than 2500 yards, set switch for 6000 yards. Set the master gain control to the point where water noise causes faint and random brightening of the sonarscope. Set the local audio control to a comfortable level or, if your supervisor so instructs, plug in the headphones.

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If an echo pip appears at the same range and bearing for several transmissions, investigate the contact. Train the cursor to the echo, and listen for doppler while you get the range and bearing. Report the contact immediately. If you have difficulty determining doppler, try several transmissions with long pulse length.

If you should be on long scale and suspect a target in close, recycle the equipment with the hand key immediately after the target echo appears. This is important because the equipment transmits only once every 7½ seconds when set for 6000-yard sweep.

The equipment may occasionally be used in LISTEN, but it should never be set for this mode of operation without the express permission of your supervisor.

Tracking

Once contact is established and you commence tracking, equipment controls should be changed as follows:

CONTROL	POSITION
VIDEO	Difference
PULSE LENGTH	Short
MANUAL ODN	Latest report of ship's speed

Keep the stabilization switch off and the transmission switch in normal when you begin tracking the target.

As you track, keep the selector switch at the fastest sweep rate that keeps the echo on the screen. Operate the gain control for the best echo resolution, but be careful not to use a gain setting so high that it defocuses the picture. Immediately after the echo appears on the screen, depress the cursor hold button and adjust the cursor until it exactly bisects the pip. Report bearings continuously, adjusting the length of the cursor to the range. Once the range recorder is cut in, it won't be necessary for you to report range. The recorder will key the equipment.

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If you have no doppler indication, try an occasional transmission on medium pulse.

If contact is lost at short range, the sonar supervisor will order the equipment shifted to MCC. If you still do not regain contact, try medium pulse and sum brightening. When contact is regained, return to difference brightening and short pulse.

In attempting to regain contact after attack, you frequently will find that the target is masked by own ship's wake. If the estimated range to the target is not more than 1000 yards, try MCC. If you do not locate the target in the wake immediately, shift to normal transmission and carry out standard search.

General Comments on Operating Procedures

TARGET ASPECT.—With good sonar conditions, you sometimes can determine target aspect directly from the scope when operating on the 1000-yard scale or in range gated sweep. Some distortion of target aspect can be expected in range gated sweep, but careful attention to the angle of the target with respect to the bearing cursor may reveal target aspect. Report target aspect without delay.

ODN CONTROL.—It is possible the report of ship's speed from the bridge is not accurate. You can check ODN compensation by training directly abeam, transmitting, and then quickly training 45° forward or aft. The pitch of reverberations should not change. If the pitch does change, readjust ODN control until no difference in pitch is noted. Report this to the sonar supervisor.

TRANSMITTER THERMAL LIMIT.—The transmitter is subject to overloading if you hand key for long periods of time, or if you operate in long pulse with the recorder in control. A protective relay in the transmitter automatically reduces power input when this happens, and the XMTR THERMAL LIMIT pilot light comes on. When the indicator lights, stop hand keying or shift to medium or short pulse.

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STABILIZATION.—On a ship equipped with a stabilization computer, stabilization should be turned off until your supervisor instructs you to turn it on. With stabilization ON, it is possible to get erratic behavior of the display. Generally, you will get continuous or erratic rotation of the stern cursor. Turn stabilization off and report to your supervisor.

REDUCED POWER.—This feature can be used to reduce interference between ships in multiple-ship operations. Again, don't set the equipment for reduced power unless doctrine or your supervisor directs. Another way of minimizing intership interference is with the difference brightening setting.

COMMUNICATIONS.—For underwater communications with the hand key, the selector switch must be in the LISTEN position. In this position, a 400-cycle modulation is imposed on the ultrasonic output of the transmitter. With the selector switch in any of the echo-ranging positions, the hand key serves only to initiate a transmission and recycle the cathode-ray tube display.

Further information on underwater communication can be found in chapter 13 of this training course.

AZIMUTH-RANGE INDICATOR

A complete azimuth search sonar set system will include two remote units, called azimuth-range indicators. A unit of this type can be seen in figure 6–18.

Controls on an azimuth-range indicator affect audio and video response of the remote unit, but do not affect operation of the sonar console. For best performance, adjust the cathode-ray intensity to a comfortable level, as you would for the sonar console. Set the signal intensity control to the midpoint, and have another Sonarman set the console master gain control to zero. With these settings, adjust the intensity control of the azimuth-range indicator until the spiral trace is just below threshold visibility. This should be at, or near, maximum setting.

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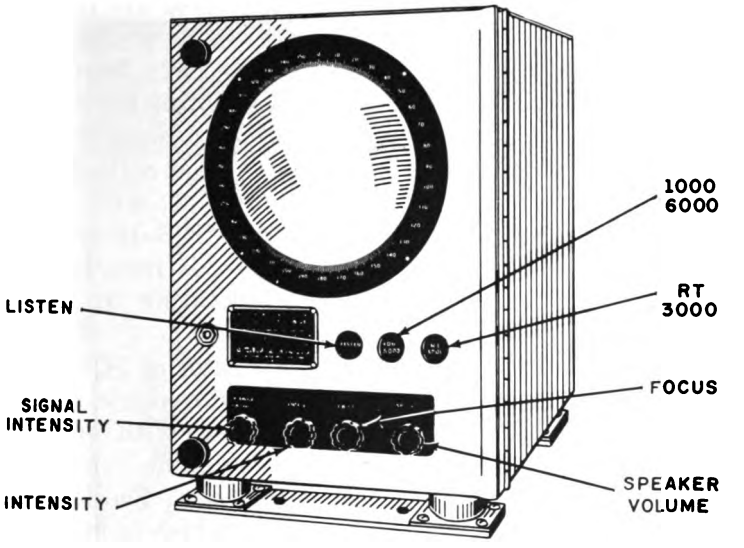

Figure 6–18.—Azimuth-range indicator.

Focus the stern cursor and, with the equipment master gain control in operating position, adjust speaker volume and signal intensity to comfortable levels.

One of three pilot lights will tell you the mode of operation of the console in sonar control. On AN/SQS–10 and –11 sonar sets, these pilots are labeled: LISTEN, 1000–6000, and RT–3000. You can tell whether the equipment is keying on 1000 yards or 6000 yards by the rate of sweep. When the RT–3000 indicator lights, it means a range recorder is keying the equipment or the equipment is keying on 3000 yards. Again, sweep rate will indicate mode of operation.

Pilot lights on the remote azimuth-range indicator of QHBa equipment indicate LISTEN, 3750, and 1500. Otherwise, there is no difference in the remote indicators.

AN/SQR–3 AND –4

Sonar Receiving Sets AN/SQR–3 and –4 are depth-determining equipments intended for use with azimuth

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STABILIZATION.—On a ship equipped with a stabilization computer, stabilization should be turned off until your supervisor instructs you to turn it on. With stabilization ON, it is possible to get erratic behavior of the display. Generally, you will get continuous or erratic rotation of the stern cursor. Turn stabilization off and report to your supervisor.

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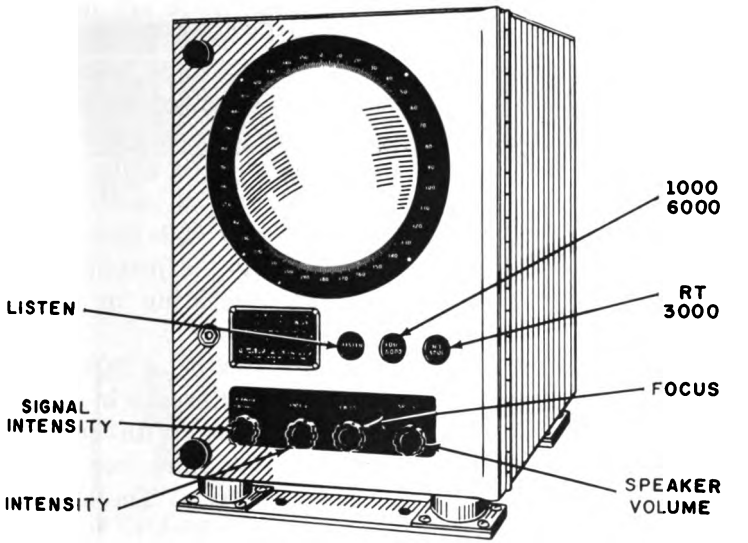

Figure 6–18.—Azimuth-range indicator.

Focus the stern cursor and, with the equipment master gain control in operating position, adjust speaker volume and signal intensity to comfortable levels.

One of three pilot lights will tell you the mode of operation of the console in sonar control. On AN/SQS–10 and –11 sonar sets, these pilots are labeled: LISTEN, 1000–6000, and RT–3000. You can tell whether the equipment is keying on 1000 yards or 6000 yards by the rate of sweep. When the RT–3000 indicator lights, it means a range recorder is keying the equipment or the equipment is keying on 3000 yards. Again, sweep rate will indicate mode of operation.

Pilot lights on the remote azimuth-range indicator of QHBa equipment indicate LISTEN, 3750, and 1500. Otherwise, there is no difference in the remote indicators.

AN/SQR–3 AND –4

Sonar Receiving Sets AN/SQR–3 and –4 are depth-determining equipments intended for use with azimuth

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search sonar sets. Strictly speaking, these are listening equipments capable of indicating the angle of depression of an ultrasonic sound source. They have been called "parasitic" echo-ranging sonars because they use azimuth search sonar transmissions to determine target depth.

The only difference between SQR–3 and SQR–4 is the operating frequency. Model AN/SQR–3, with a frequency of 20 kc, is installed with AN/SQS–10 or –10A; and AN/SQR–4, operating at 25.5 kc, is installed with AN/SQS–11, –11A, or a QHBa operating at exactly 25.5 kc.

Figure 6–19 shows the control indicator of SQR equipment. As you can see, there is little difference in appearance between SQR and SQS consoles. With only one exception, the top panel contains the same controls as AN/SQS–10 and –11 azimuth search sets. The lone difference is the SEARCH ON-OFF switch, which occupies the position of the MCC-REDUCED POWER-NORMAL switch of azimuth search sets.

The search switch is turned on when SQR–3 or –4 is used as an independent echo-ranging sonar (still using azimuth search sonar transmissions). With the switch on, you can search for echo-producing objects directly ahead of the ship, while the azimuth search operator investigates some other bearing.

Three controls on the front panel are familiar from your study of azimuth search equipment: MASTER GAIN, SELECTOR SWITCH, and TRAIN CONTROL. The master gain controls video and audio gain. The selector switch has listen and range gated positions, as do azimuth search sonars, but echo range settings are 750, 1500, and 3000.

Cursors

When SQR equipment is set for echo ranging, a solid line cursor prints each time the equipment cycles. Essentially, this is the same cursor used for bearing indication in azimuth search sonar. In SQR it measures the angle

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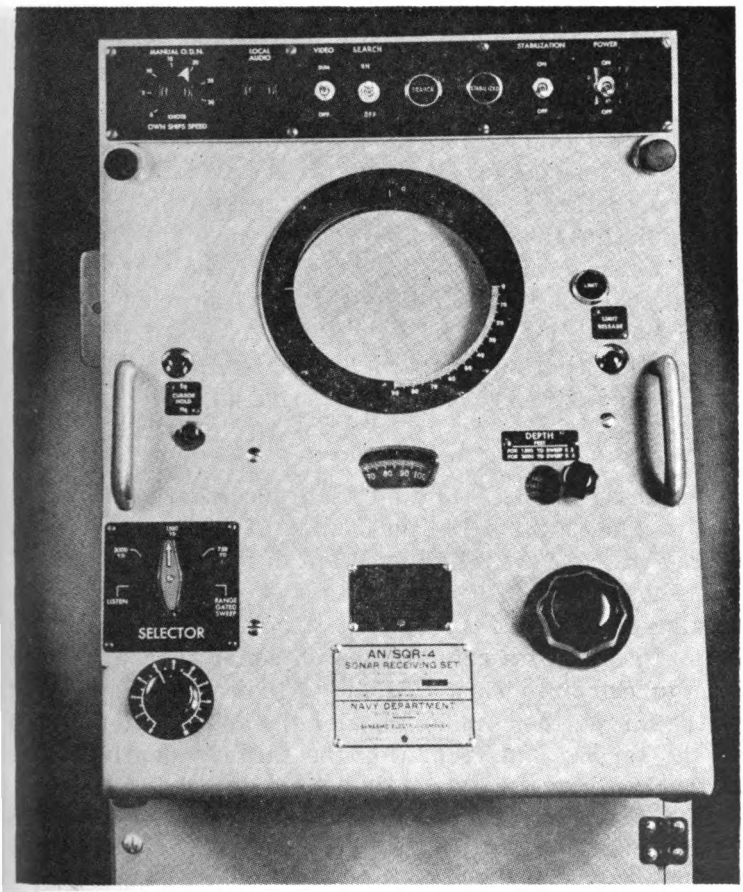

Figure 6–19.—AN/SQR–3 and –4 console, showing operator's controls.

of depression of the sound beam to the target with respect to the ocean surface. It is called the depression angle cursor and carries the symbol *Eq*. The training control knob moves this cursor radially through a calibrated quadrant of 90°, and a small dial under the cathode-ray scope indicates depression angle. One revolution of the training control knob rotates the cursor 20°; it can also be slewed right or left at 8 rpm.

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With the selector switch set for listening, a double-dotted listen cursor appears on the scope, as it does in azimuth search sets. Depression angle of the listen cursor is also controlled by the training knob.

A feature unique in SQR equipment is a horizontal cursor for estimating target depth. It is called the *Hq* cursor because the fire control symbol for target depth is *Hq*. By manipulating the depth knob, you can move the *Hq* cursor up or down to bisect the target pip. Once the pip is bisected, a small dial near the depth knob provides a depth reading in feet.

A pair of buttons marked *Eq* CURSOR HOLD *Hq* allows you to hold either cursor on the scope at will.

Transducers

Model AN/SQR–3 and –4 transducers are similar in design and operate on the same principle as azimuth search transducers. The important difference is that SQR transducers search vertically, that is, in a plane perpendicular to the deck through the fore-and-aft axis of the ship. In effect, an azimuth search sonar transducer has been turned on its side. Instead of indicating the bearing of the target, the cursor indicates the angle of depression of the target, and from this the target's depth can be determined.

The arrangement of transducer elements can be seen in figure 6–20. The transducer is approximately 28 inches in diameter with a maximum thickness of 7 inches and is protected by a streamlined housing. It contains 48 magnetostrictive elements around 240° of a mounting cylinder. Roughly considered, each element covers a 5° sector. There are no elements in the upper aft quadrant, or 15° on either side of it, because this sector is masked by the ship's hull.

Scanning Switch

Because of the design of the transducer, the video scanning switch of SQR–3 and –4 equipment scans only 240°.

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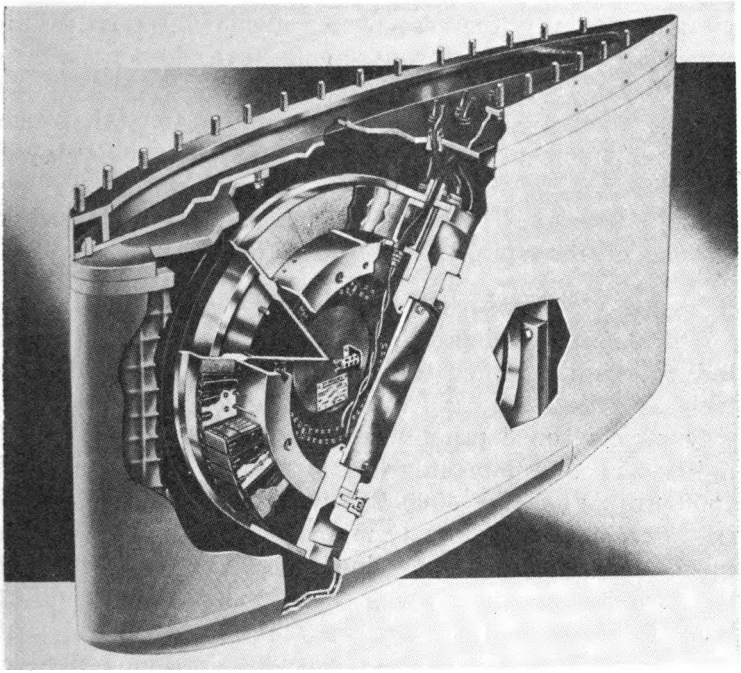

Figure 6–20.—AN/SQR–3 and –4 transducer, showing arrangement of elements.

The stator in the video scanner is divided into two groups of 48 segments, each group spanning 120°. The rotor contains two groups of 24 segments, each group spanning 60°. Each segment in the rotor and stator is connected electrically to a corresponding segment in the other group so that 1 revolution of the rotor produces 2 complete scanning cycles. The scanning switch rotor speed is approximately 3000 rpm, or 100 scanning cycles per second.

Energizing and Adjusting

The procedures for energizing and making the preliminary adjustments to SQR sets are almost identical with procedures for SQS equipment. During warmup, the selector switch should be in the listen position. Thirty

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seconds after you turn on power, you should receive audio response; in 60 seconds you should have video presentation.

Even though SQR operation is similar to SQS, make all adjustments in accordance with *Instruction Book for Sonar Receiving Sets AN/SQR–3 and AN/SQR–4,* NavShips 91545(A). Have an experienced Sonarman check you out on the equipment the first time.

DEPRESSION-DEPTH INDICATOR

The depression-depth indicator is the azimuth-range indicator unit adapted for use with SQR–3 and –4. Controls are the same, and manipulation of controls in no way affects the depth-determining sonar console. Pilot lights on the remote unit read: LISTEN, 3000–750, and 1500–RT. When the 3000–750 indicator lights, it means the equipment recycling time allows it to receive echoes up to 3000 or 750 yards. The sweep rate tells which of the two keying intervals is being used. The 1500-RT lamp indicates a 1500-yard recycling interval, or that range tracking is being controlled by a range recorder. Sweep rate will again tell you the mode of operation at the depth-determining console.

SEARCHLIGHT SONARS

Searchlight-type sonars are used in harbor defense and may be found aboard ships of the Reserve Fleets, but few, if any, remain on ships of the operating forces. Sonar sets of the searchlight group use a directional transducer to concentrate an outgoing pulse of sound into a narrow beam. Target bearing is determined by training the transducer for maximum echo strength. The only response is audio, and a thorough underwater search is a slow, step-by-step process.

Model QGB

Model QGB searchlight sonar equipment was designed during World War II for installation in destroyer escorts. (See fig. 6–21.) This system uses a magnetostrictive

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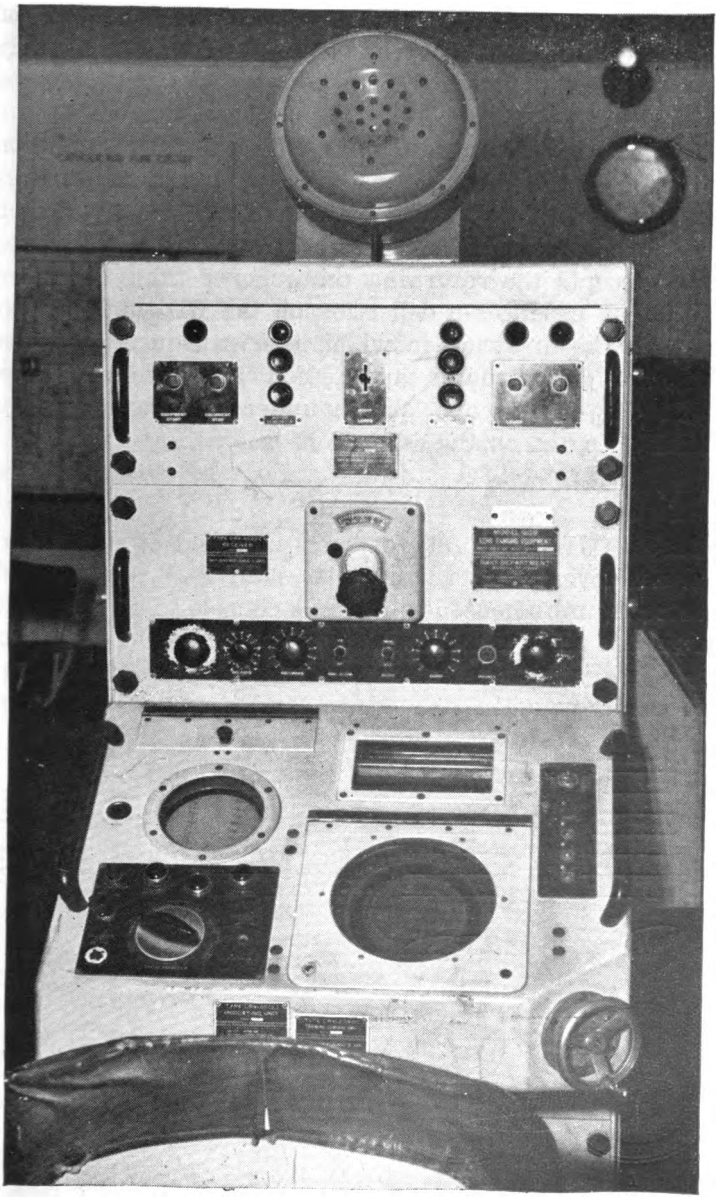

Figure 6–21.—Model QGB sonar console.

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transducer, and is tunable over a frequency range of 17–26 kc. However, any change of operating frequency means the magnetostrictive transducer must also be changed.

Model QGB is equipped with BDI (bearing deviation indicator) to assist the operator in staying on center target. For BDI, the transducer is split electrically. When the transducer is not on center bearing, half of the transducer accepts the returning echo sooner than the other half. This produces a deflection on the BDI cathode-ray scope in the direction in which the transducer must be trained to get on center target. You can see this in figure 6–22. The BDI scope, shown under the transducer, is actually located on the sonar console.

Model QJB

Model QJB sonar set, formerly installed on destroyers and destroyer escorts, is smaller than QGB, and has all electronic units housed in a single console. The transmitter in this sonar set is of lower power than the QGB, but use of a crystal transducer produces transmission energy and echoes equal in strength to the larger, magnetostric-

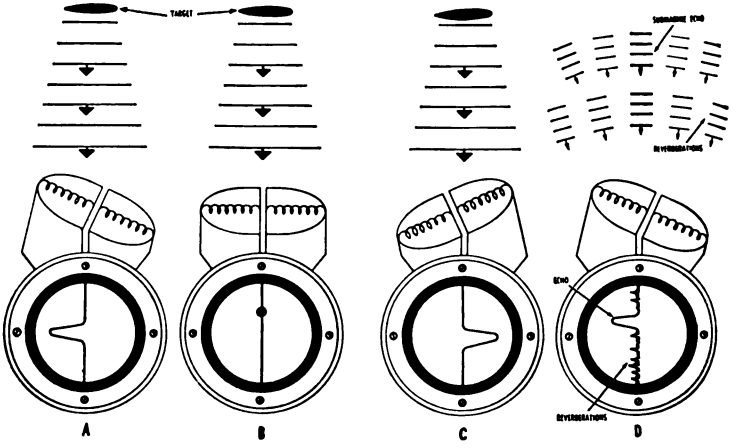

Figure 6–22.—BDI and transducer train.

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tive QGB. In appearance, QJB differs from QGB in that the BDI cathode-ray scope of the former is mounted in the center of the bearing circle. The operator does not shift his eyes away from the transducer bearing indication to see BDI.

Model QGA

Model QGA sonar set includes two complete sonar equipments. One operates on a frequency of 14 kc and the other on 30 kc. The 30-kc transducer can be depressed through an angle 0° to 45° to hold contact with deep targets. You see the two transducers illustrated in figure 6–23.

The two equipments in the QGA set can be operated independently or slaved. The transducers (magneto-

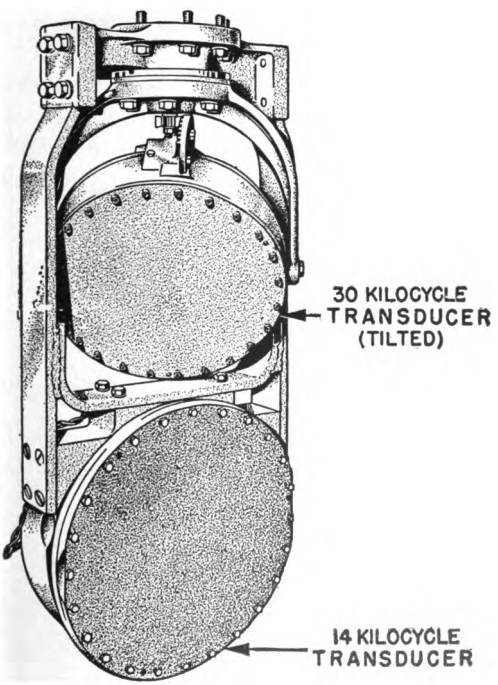

Figure 6–23.—Model QGA sonar transducers.

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strictive) are mounted on concentric shafts, and are hoisted and lowered together. The 30-kc transducer is the smaller and is mounted over the 14-kc transducer. Training mechanisms are arranged so they can be trained independently of each other.

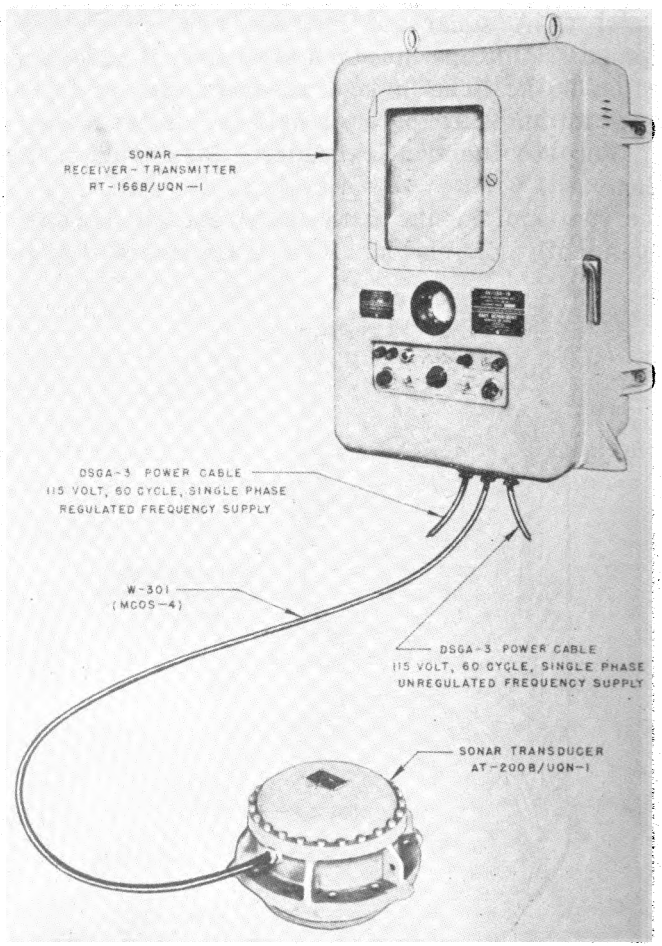

Figure 6–24.—AN/UQN–1B fathometer.

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AN/UQN–1B

Model AN/UQN–1B echo-sounding equipment is the most modern and up-to-date fathometer installed in ships today. It replaces both the NMC and NJ series. As you can see in figure 6–24, the set includes a compact receiver-transmitter unit and a transducer. In spite of small size, it gives very accurate readings at a wide range of depths, from about 5 feet to 6000 fathoms. It is designed for use on both submarines and surface vessels.

Three recorder ranges are provided: 0 to 600 feet, 0 to 600 fathoms, and 0 to 6000 fathoms. In addition to recorder chart indications, two visual indicator ranges are available: 0 to 100 feet and 0 to 100 fathoms. The equipment may be keyed manually or automatically.

When the fathometer records, a stylus starts across the recorder chart simultaneously with the emission pulse. The stylus moves at a constant velocity and marks the paper twice—once at the top of the chart when the pulse is transmitted, and again down on the depth indication when the echo returns. A typical UQN–1B depth recording can be seen in figure 6–25.

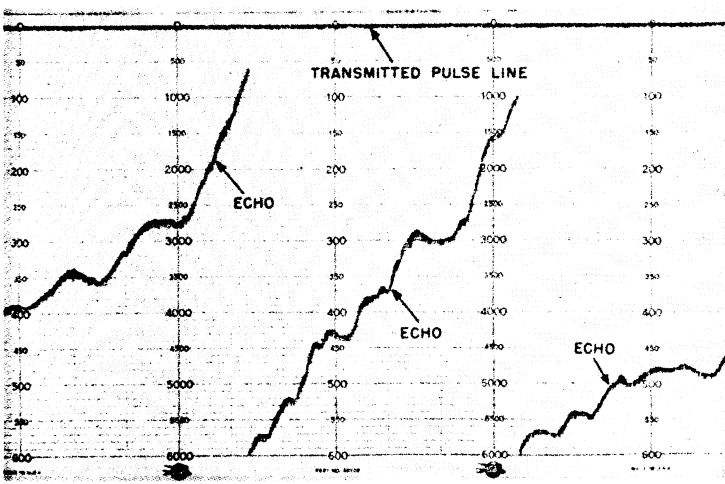

Figure 6–25.—Typical AN/UQN–1B depth recording.

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Visual indication is supplied by a circular sweep on the face of a scope tube. Transmitted pulse and returning echo radially mark the sweep trace.

FLEET DOCTRINE

The procedures you have studied conform with the manufacturer's instructions for the operation of your equipment, but you may find that fleet doctrine varies in some respects from these instructions. The next chapter will tell you how to conduct an efficient underwater search. Classified procedures for operating sonar equipment can be found in *Sonarman 3 and 2,* Vol. 2, NavPers 10139.

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QUIZ

1. What two types of display does azimuth search sonar provide?
2. What are the three steps of the underwater search process?
3. Name the two jobs the receiver-scanning assembly performs.
4. What are the three choices of pulse lengths in milliseconds on AN/SQS–10 sonar equipment?
5. How do screw noises appear on the CRT?
6. How many transducer staves are used in AN/SQS–10 and –11 equipment to form an acoustic beam?
7. How many segments are in the audio and video scanning switches of the (a) QHB equipment? (b) The SQS–10 and –11?
8. What do the following fire control symbols mean? (a) *Bq.* (b) *Brq.* (c) *Co.* (d) $\triangle B'r'q$.
9. Name the three cursors available in AN/SQR equipment.
10. How many degrees do AN/SQR transducers scan? What is the scanning rate?
11. Before communicating by using the azimuth search hand key, in what position must the selector switch be?
12. Three models of searchlight sonar are QGA, QGB, and QJB. Which of these has a crystal transducer?
13. Which model of searchlight sonar has two transducers?
14. What are the three recorder ranges of AN/UQN-1B equipment?
15. How long should you wait to echo range after energizing AN/SQS–10 or –11 equipment?
16. What does the lighting of the XMTR THERMAL LIMIT indicator mean when azimuth search equipment is set for normal operation?

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CHAPTER 7

OPERATING THE CONSOLE

DO IT WELL

Operating the sonar console during the many months of search and the few minutes of contact is the duty for which you are trained. Few duties are as important as this—for by your skill and alertness you may save your ship and the ships of other men from destruction by submarine attack.

The procedure you will study in this chapter applies to scanning as well as searchlight equipment. In searchlight sonar you train the sound beam; in scanning you train the audio cursor sector of the scanning switch. In terms of underwater search, these actions are practically similar.

When searching for a submerged submarine, you alone can make the original contact. Once made, it is you who must hold the contact for attack and reattack. The whole ship is waiting in readiness to act upon the information you are furnishing from your equipment. The men on the fantail with the depth charges, plotters in the combat information center keeping a tactical plot, the conning officer directing the course of your ship—all are depending on the information you call out. Don't let them down by failing at your job.

LEARN NOW THE PROCEDURE THAT IS GOING TO HAVE

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SUCH IMPORTANCE WHEN YOU HAVE CONTACTED A SUBMERGED SUBMARINE. The Navy has no place for a poor Sonarman. Your duty is too important to be poorly performed.

So that your job may be done well, a precise procedure has been developed. Follow this procedure—it will enable you to give the most and the best information. As new facts are learned, the procedure will change. So keep up to date by studying NWP's, NWIP's, and type commander instructions.

SCOPE INTERPRETATION

The advantages of scanning sonar can easily be lost if you do not interpret the information on the scope properly. In searchlight sonar you generally watch the pointer as you train the transducer searching for the submarine. In scanning sonar this would amount to concentration on the audio cursor line and THAT IS ABSOLUTELY WRONG. You can get that information with your ears; your eyes should search the scope for echoes that are being presented visually only. On the other hand, don't keep your eyes concentrated on the expanding sweep circle. Take a quick scan of the entire scope just before each ping and pick out possible target pips or noise spokes. On the next ping, watch to see if those pips repeat. All information, whether reverberations or target echoes, will remain on the scope for the duration of the sweep. Remember, water noises and reverberations print for only one sweep of the scanning channel across any given bearing. An echo from a submarine will last long enough for the video channel to scan it twice or more. A submarine which is beam-on may last for only one sweep, but you can distinguish it from reverberation echoes by its brightness.

NEVER IGNORE AN AUDIO SIGNAL SIMPLY BECAUSE IT ISN'T A BIG PIP ON THE SCOPE. The audio echo from a submarine is still your most important single source of information.

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Do not interrupt your audio step-by-step search to investigate every visual presentation that looks like a target. When you check a pip that looks like a submarine, watch it for two or three sweeps. If it repeats itself at the same range and bearing, train the cursor to the bearing and investigate. There will be times—once you become an experienced operator—when your first glance at the pip tells you it's a submarine. In such a case, slew the cursor to the target bearing immediately. BE ON THE ALERT FOR SUBMARINE OR TORPEDO NOISES. These will appear as bright wedges on the scope.

Scopes of two azimuth search sonars are shown in figures 7–1 and 7–2. The first illustration is a submarine target with wake and hydrophone effects photographed from a QHBa scope. The second shows a beam aspect submarine "seen" through an assisting ship's wake. This is a photograph of an AN/SQS–10 sonarscope.

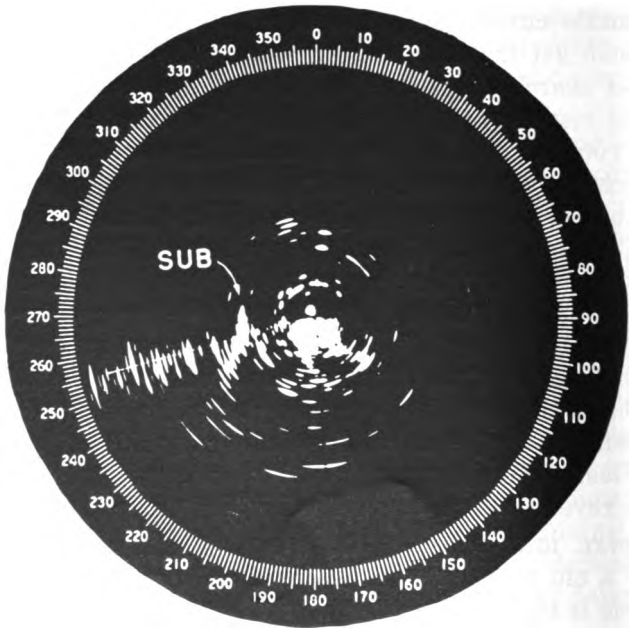

Figure 7–1.—Submarine—wake and HE.

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Figure 7–2.—Submarine bears 265°T; own ship's wake bears 010°T.

MCC Switch

Use of the MCC switch will help you tell whether the echo is coming from a ship's wake or from a live target. Switching on the MCC will decrease the intensity of the wake echo and usually make the target echo stand out. As the range on the target closes, turn on the MCC switch to see if your echo improves. In any case, always have the MCC switch on when contact begins to weaken due to short range.

If a submarine increases its speed radically during an attack, the noise output may mask the echo. To get good bearings, be sure your cursor bisects the noise sector on the scope. Watch the target carefully. When operating against high-speed submarines you may find in the final stages of the attack that the bearing of the returning echo is slightly to one side of the noise spoke. Often, informa-

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tion on submarine turns can be obtained first by this bearing difference of the noise spoke and the submarine echo.

Here is what is happening: The source of the submarine echo is near the conning tower of the submarine. The noise source is at the stern of the submarine. Separation of the noise spoke and submarine echo indicates a target turn in the direction of the echo bearing. For instance, if the echo appears to the right or on the right edge of the noise spoke, it may indicate that the submarine has commenced turning to your right; if the echo appears to the left, a turn to the left may be indicated. The separation between the echo and the noise spoke is not always pronounced and may be only 1° or 2° in bearing. As the target approaches beam aspect, this difference in bearing may become as much as 5° to 10°.

With a beam target, a DECREASE in the bearing difference may also indicate a turn. Furthermore, the higher speed submarines can leave a wake which also prints on the scanning sonarscope and can be used to help determine target aspect.

Controlling the Gain

You can get best bearing information by adjusting the gain for a clear picture on the scope. Beam targets return very strong echoes which cover a large arc on the scope. The gain in this case should be reduced to decrease the size of the printed arc.

But don't forget that manipulating the gain control will affect other equipments in the system. The gain must be kept high enough to obtain good target presentation on the AP scope, and must be adjusted to print satisfactory traces on range recorders. Under all conditions, the gain must be adjusted to print satisfactory traces on the recorders.

When a contact at short range is masked by reverberations, it's usually better to reduce the gain. What you want is the best possible echo-to-reverberation ratio. A low

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gain is your best bet. Some operators immediately increase gain when reverberation interferes. This strengthens the echo, but it also tends to lose it in the increased amplitude of the reverberations. If the echo fades during an attack, report the fading immediately. Experiment with the gain setting, and cut the MCC switch on and off. A fading echo isn't likely to reappear unless you do something about it.

DOPPLER WITH SCANNING SONAR

Doppler is frequently the only positive means of classifying a submarine echo and, as you learned in chapter 4, it provides the earliest indication of a submarine maneuver. Unfortunately, doppler determination with scanning sonar is much more difficult than with searchlight for the following reasons:

1. No clearly defined reverberations are present with which to compare the pitch of the returning echo. Thus, doppler determination with scanning is almost entirely a memory operation. You compare the pitch of the echo with an imaginary 800-cycle tone.
2. Wake echoes of varying pitch are received from nearly all bearings and produce false references for comparing echo pitch.
3. Three to six pings, with cursor trained on the same echo bearing, are required before own doppler nullifier circuit stabilizes the pitch of the echo at the correct frequency (above 800 cycles if up doppler, at 800 cycles if no doppler, and below 800 cycles if down doppler).
4. Short pulse length makes it difficult to determine doppler.

Even so, a skilled operator can pick out doppler correctly three times out of four. It is easy to detect marked doppler, such as a high-speed submarine at bow or quarter aspect. Slow, beam aspect submarines are the most difficult. Here are some recommendations to help you determine doppler with scanning sonar.

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1. Keep gain low to improve pitch discrimination.
2. Do not attempt to determine doppler on one or two pings unless it is marked. Wait for several pings, so that the echo pitch becomes stable.
3. Use long pulse length for easier doppler recognition if the sonar console has a switch for different pulse lengths.
4. If reverberations can be heard, use the first ones as a reference for comparing echo pitch. Disregard the wake echoes, which will be at varying pitches.
5. Memorize the pitch of no doppler echoes—800 cycles—and compare the echo with the memorized tone.
6. Use training aid recordings frequently.

THE SEARCH

A search is any organized plan for detecting a submarine. The procedure for searching is designed so that you can cover the largest area of the ocean with your sound beam in the fastest time and still be able to detect the submarine if present. The rules for searching are fairly simple, but all details are not given because of classification.

The first rule is to SEARCH FROM AFT FORWARD. The reason for this is illustrated in figure 7–3. In the left-hand illustration you can see the search arc when you begin on the port beam and search forward. Your ship moves through the water while your equipment transmits, and when you search from aft forward you do not cover any area twice.

If you searched from the bow aft to the beam, you would not cover as much ocean territory; you would be searching some areas twice, and there would be a large unsearched area in this pattern. You can see what happens when you search from forward aft by looking at figure 7–3B.

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Here is your second rule: Always search in 10° steps. Although the audio channel is about 15° wide (approximately 7½° on either side of the cursor), the receiving beam width is considered to be only 10° for EFFECTIVE underwater search.

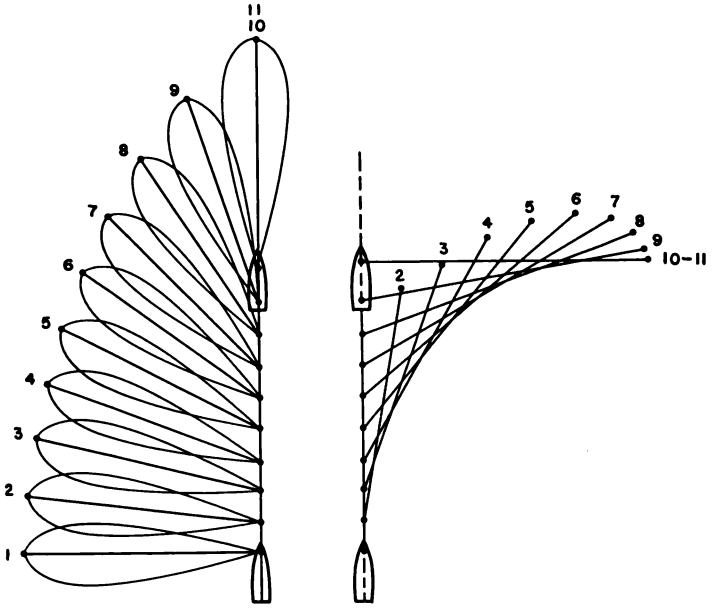

Figure 7–3.—A good search plan covers a large area.

Look at figure 7–4 and you can see that steps smaller than 10° will take too much time.

Your next rule is PING—TRAIN—LISTEN. This means send out a transmission, train to the next bearing, and then listen for an echo. Practice this until you automatically can train forward in 10° steps exactly. Twelve degrees on one step and 7° on the next step is sloppy operating. By practicing the PING—TRAIN—LISTEN routine, you'll be able to search more efficiently. You won't have to think about training the audio cursor when you should be listening.

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You must always send TWO PINGS ON THE BOW. The reason for this runs into a short tale: You will normally search an arc from one beam to the other beam. If you started at one beam and searched forward to the bow, and then continued through the bow down to the other beam,

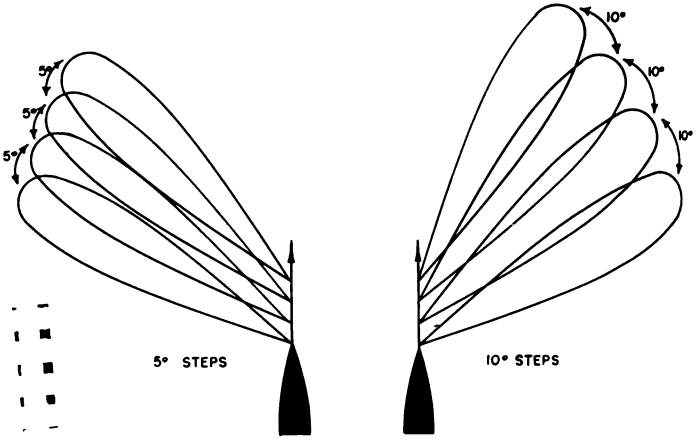

Figure 7–4.—Use exactly 10° steps.

you would be searching the last half of the arc from the bow AFT to the beam. You know from the discussion about figure 7–3B that this is a poor practice. Therefore you divide this large beam-to-beam arc into two parts. You PING—TRAIN—LISTEN from the beam to the bow; and when you get to the bow, you PING TWICE, slew to the other beam, and start forward again.

Suppose there was a submarine directly ahead of you. If you sent out the ping directly ahead and then immediately trained to the beam, you would not be trained at the bearing of the submarine when the echo came in. To make sure you'll get the bearing of the echo, always send out two transmissions on the bow before you train the audio cursor aft. This procedure is illustrated in figure 7–5. You'll appreciate the illustration more if you start with ping No. 1 on the starboard beam and follow the numbers around the arc.

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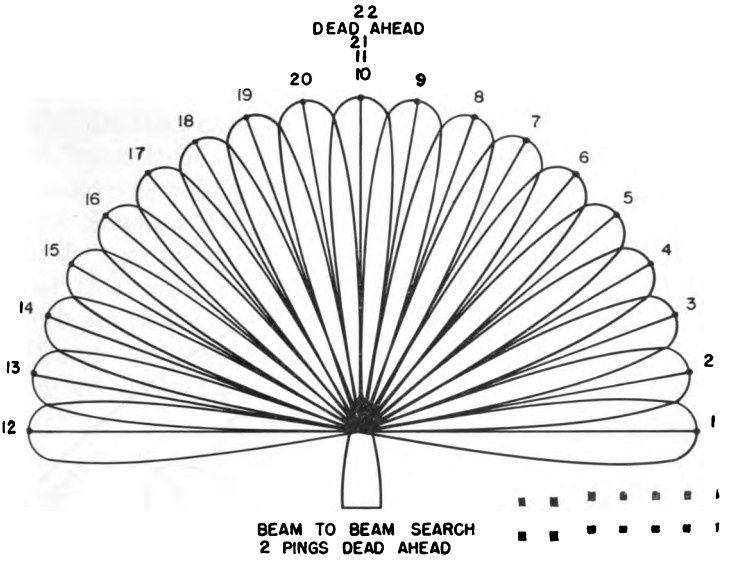

Figure 7–5.—Send two pings on the bow.

There is one exception to this TWO-PINGS-ON-THE-BOW rule. If one of the limits of your search arc lies within 30° of the bow, start at the aftermost limit and search right through the bow, sending out two pings at the end of the arc instead of on the bow. Then repeat this search procedure. The reason for this is that the arc is too small to divide into two areas. It is much more efficient to cover this smaller area in one arc. Look at figure 7–6 for a pictorial explanation of this procedure.

The order to search an arc will be given to you by the A/S or CIC officer. For instance, "Search arc 070° to 350°." (Assume he means true bearings unless he says it's to be relative bearings.)

You reply in exactly the same words to be sure you understood the order. So your answer will be "Search arc 070° to 350°."

Then you begin to search the arc. You search it over and over again with no report unless you hear an echo or receive new instructions.

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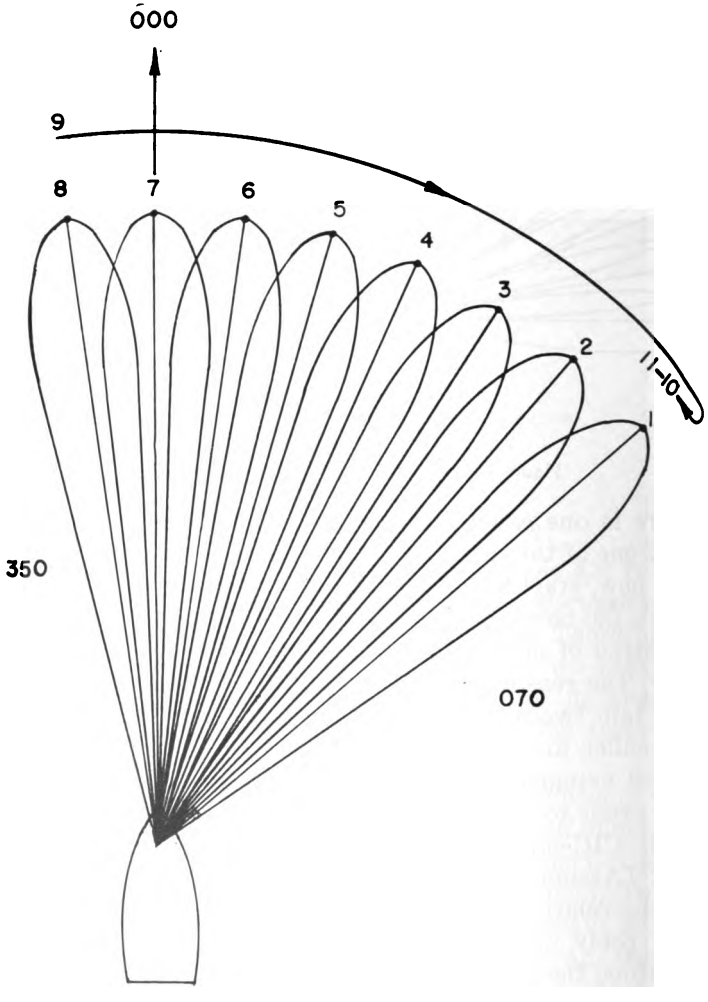

Figure 7–6.—A search arc within 30° of the bow.

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Investigating an Arc

If the presence of a submarine is suspected in a particular area, the order will be "Investigate arc 040° to 010°." In that case, you reply "Investigate arc 040° to 010°," and then investigate the arc once, using the same procedure as before, EXCEPT THAT YOU WILL TRAIN IN 2.5° STEPS. Send out two pings on the forward limit and then repeat "Arc investigated, no echo" if you hear no echoes. After this, you resume the original search arc, starting where you were interrupted.

If you hear an echo while investigating an arc, develop the contact as you would in the search procedure.

CONTACT

When you hear an echo, report it immediately. Say "Sonar contact, bearing—, range—." Always say HUNDRED (not double-oh) when reporting ranges in even hundreds of yards. Thus, a range of 1500 yards is reported: "Range one five hundred." When ranges are not in even hundreds, pronounce each numeral. Thus, a range of 1150 is reported: "Range one one five zero." (In this case say zero, NOT oh.) Some examples are: 1100 yards (one one hundred); 1200 yards (one two hundred), 1350 yards (one three five zero), etc. The only time the sonar OPERATOR gives the range is at this first contact. Ranges are reported by the RANGE RECORDER operator thereafter.

Ping—Listen—Train

Once you establish contact, there is an important change to make. Instead of training the audio cursor when the signal is sent out, you train it after the echo comes in but before the next ping goes out. In this way, you are trained directly at the submarine as the echo comes back. So the routine at contact is ping, listen for the echo, and when the echo comes in, train to the next position. Instead of PING—TRAIN—LISTEN as you did while searching, you now PING—LISTEN—TRAIN.

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After you report the sonar contact, you must make a preliminary determination of the source of the contact. The final decision will not be yours, for accurate classification of a target depends on many factors.

After you report the contact, the OOD checks the bearing visually and the CIC checks it on radar to see if there is a surface ship or school of fish on the bearing and range you called out. The report will be either "bearing foul" or "bearing clear." If the bearing is foul, resume the search procedure. If the bearing is clear, continue to develop the contact so you can help classify the target you have detected. At this time you should expect a change of course toward the bearing you have reported.

How To Classify the Contact

You will start by training 5° aft of the original contact bearing and listening for the echo. If an echo comes back, again train 5° toward the stern. Keep doing this until you are off the target, that is, until no echo comes back. As soon as this happens, ping—listen—train back toward the bow in 2.5° steps. As soon as you hear the echo again, report this bearing as "Right (left) cut....." Now train across the target in 5° steps until you go off the other end of the target, that is, until there is no echo. Then train back onto the target in 2.5° steps until you hear the echo again. Report this bearing as "Left (right) cut....." Then bisect the pip with the cursor and track smoothly. Figure 7–7 will give you a clear picture of a left and a right cut.

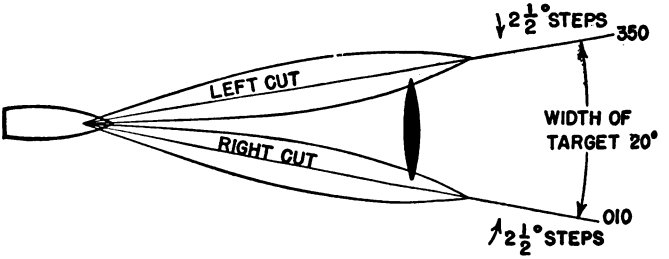

Figure 7–7.—Make your cuts accurate.

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A right cut is the bearing on which you first hear the echo when you train the audio cursor back on the right end of the target. The left cut is the bearing on which you first hear the echo when you train back on the left end of the target. The distance between these two bearings is the target width. You report this as "Target width,..... degrees."

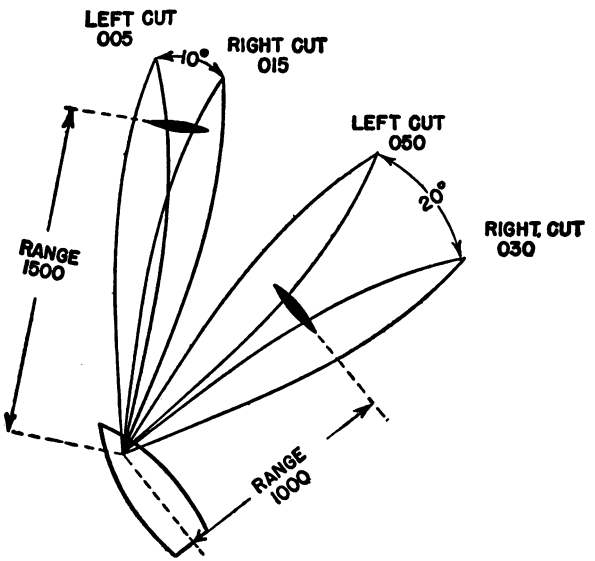

Figure 7–8.—A wake would be much wider.

The width of the target is an important aid in classifying the echo. If the target is a submarine, it will have a fairly narrow width at long ranges. With a shallow submarine this width may be only 2° or 3° at a range of 2000 yards, or it may be as much as 20° at a range of 1000 yards. Look at figure 7–8 and you can see that as the range becomes shorter, the target width becomes greater.

EXCEPTION: With a very deep submarine, the target width does not widen as much at short range as it does with a shallow submarine. A deep submarine is caught

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only by the narrow bottom of the sound beam; a shallow submarine is up in the wide middle of the beam.

After you have reported target width, you must report the doppler. You already know how important doppler is in classifying the target. As soon as you report doppler, report whether the echo is sharp or mushy. If it seems to be clear on one cut and mushy on the other, report that too. The bow cut of a submarine should be clear and sharp, while the stern cut will be mushy because it is at the stern end that you hear the wake echo. So report the side of the target where wake is encountered, and the side of the target where the echo strength drops off sharply.

You can also send out a pair of short signals—di-dit—with the hand key and listen for the echo. If the echo comes back from a good reflecting surface, it will sound like the signal you sent out—di-dit. If it comes back from a poor target, the echo will not have that characteristic sound. This may help you to classify your contact.

Four Classifications

Classification of a target is a command function. This means that the commanding officer ultimately decides whether the contact you have is a submarine. His decision will be based on information supplied by your sonar set, the sonar team, CIC, surface lookouts, and all other members of the antisubmarine team. In all, there are four classifications for underwater targets, and you should understand what you are expected to contribute before accurate classification can be made.

The first classification is POSITIVE SUBMARINE, and the primary source of information is not sonar. A positive submarine is a surfaced submarine, submerged submarine, periscope, or snorkel sighted and identified by personnel competent to recognize positively such objects. Of course, range and bearing by sonar would add further confirmation.

The second classification is PROBABLE SUBMARINE and

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here is what sonar must furnish before a contact can be so classified. All of the following, observed and reported by competent personnel, must be accomplished: (1) Tracking of a firm sonar contact for a total of at least 30 minutes with courses, speeds, echo quality, and doppler effect compatible with submarine characteristics and confirmed by appropriate change of target aspect in recorder traces and by the target track as plotted on the DRT or by other means; and (2) one or more of the following, heard or detected: Radar contact confirming the sonar track, propeller noises, internal submarine noises, sonar signals, sonar jamming, pronounced hydrophone effect if the track indicates submarine moving at high speed, or pronounced wake effect if track indicates submarine moving at sufficient speed.

A POSSIBLE SUBMARINE is one in which a sonar, radar, ECM sonobuoy, or MAD contact is investigated or tracked without confirming all of the characteristics listed for PROBABLE SUBMARINE, but which is suspected to be of submarine origin by competent personnel; or, surface flares, blinker lights, tracer lights, and similar indications which are thoroughly investigated and do not lead to submarine sighting or sonar contact but are suspected to be of submarine origin by competent personnel.

NONSUBMARINE is a classification which applies when a contact has developed characteristics definitely not submarine. This category normally is used when referring to a previous contact that was assigned a higher classification, but which, according to the rules of classification, does not measure up.

The table on page 220 is a quick review of what you say and do when you make sonar contact.

LOST CONTACT

It's a sad fact, but every now and then you will lose contact with the submarine. Sometimes it's your fault, but often there is absolutely nothing you can do about it. For instance, there may be a skip distance. Regardless of why

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REMEMBER TO PING—LISTEN—TRAIN AS SOON AS YOU MAKE CONTACT!

What you say	What you do
"Sonar contact, bearing_____, range_____." (Conn reports "Bearing clear.")	Train aft in 5° steps until off the target. Then train back in 2.5° steps to get the after cut.
"Right / Left cut_____."	Using 5° steps, train forward across the target and get the other cut.
"Left cut_____."	You obtain this cut by going off the target and coming back on again in 2.5° steps.
"Right"	
"Target width,_____degrees."	You get the target width by determining the difference between the two cuts.
"Doppler (low, high)," or "No doppler."	Listen to the difference in pitch between reverberation and echo.
"Sharp / Mushy echo"	Determine the quality of the echo—sharp, mushy, loud, soft, and so on.
"Wake on left / right cut."	Determine side of target where wake is encountered.
"Positive sub / Probable sub / Possible sub / Nonsub echo."	Finally classify the nature of the echo.

the contact was lost, you must regain it as soon as possible. The lost contact procedure will enable you to do this.

There are two types of lost contact—lost contact at long range and lost contact at short range. Your actions at the console will be different with each of these types.

Lost Contact at Long Range

First, let's consider lost contact at long range.

Suppose you have made a contact and are in the process of classifying it. Suddenly no echo comes back from the bearing where you think the target should be.

AFTER YOU HAVE SENT OUT FOUR OR FIVE PINGS, AND

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THERE IS STILL NO ECHO, REPORT "No echoes, last bearing ——." Make sure that you report this as soon as you have sent out four or five pings with no submarine echoes.

You should remember on which bearing you heard the last GOOD echo. Immediately after reporting "No echoes," train to the bearing 20° aft of the last good bearing you had before losing the echoes. Search forward from this point in 10° steps. Use the ping—train—listen search procedure until you are at a point 20° forward of that last good bearing. Thus you have searched a total arc of 40°.

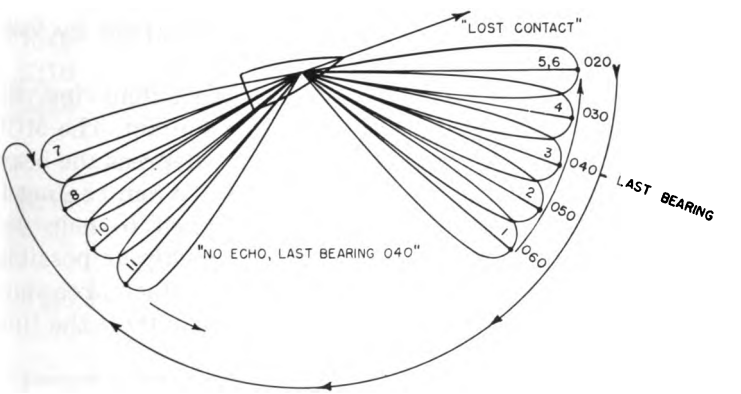

Figure 7–9.—Don't hesitate to report, "No echoes."

If you still have not regained contact, report "Lost contact." Then, the A/S or CIC officer should give you a new arc to search. But until he is able to get a new arc from the plotting team, you must train the audio cursor immediately to the stern or to the forward limit of the baffle plate and begin searching forward on the side on which you lost contact. Search up to dead ahead, using 10° steps and, of course, you will ping—train—listen. The lost contact procedure for long range is illustrated in figure 7–9.

Here, in brief, are the things you will do when you lose contact at long range:

1. After four or five pings without echoes, you will report "No echoes, last bearing——."

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2. Search an arc from 20° aft to 20° forward of the last bearing on which you had contact. Transmit twice on the forward limit.
3. If you do not regain contact, report "Lost contact."
4. Go immediately to the stern, or baffle, and search (10° steps) to dead ahead on the side on which contact was lost.

Lost Contact at Short Range

You will lose contact at short range when the submarine begins to pass under—and therefore out of range of—your sound beam. You can see how this happens by looking at figure 7–10.

You can also see that the deeper the submarine, the longer the range at which you will lose contact. The MCC feature in scanning sonar permits you to depress the beam and thus hold contact to shorter ranges. When contact is lost, you must follow procedures designed to help you regain contact with the submarine as quickly as possible. Here is one type of single ship regain contact procedure for use after depth charge attacks. CIC controls the time

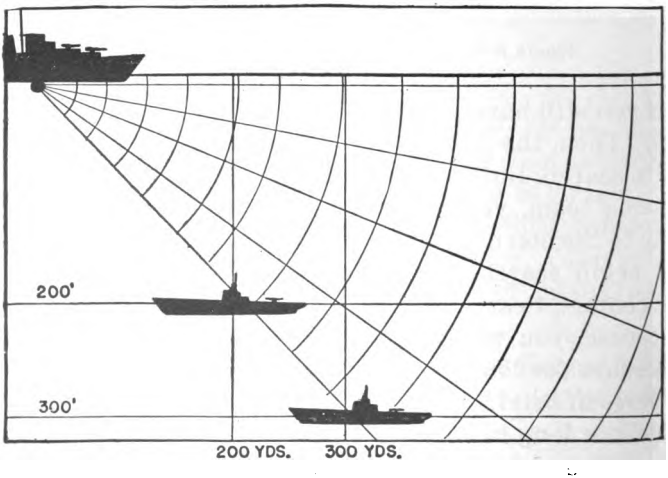

Figure 7–10.—Be ready for this.

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and provides you with necessary search arcs. In the step-by-step procedure below, the ship makes both turns in the same direction, and all search arcs are given in true bearings.

TIME	PROCEDURE
00	Center charge dropped.
20	SHIP COMMENCES TURN
40	Set cursor for fixed search 45° abaft beam on side to which ship is turning.
1:20	Commence search forward in 10° steps to broad on bow.
1:40	Search aft in 10° steps to 45° abaft beam.
2:10	Search forward in 10° steps to bow.
2:40	Slew cursor to 45° abaft beam on same side to which ship is turning. Search forward in 10° steps to bow.
3:10	Again slew cursor to 45° abaft beam on same side. Search forward in 10° steps to broad on bow.
3:40	SHIP COMMENCES NEXT TURN.
4:00	Slew to 45° abaft beam on OPPOSITE side. Search forward in 10° steps to bow.
5:00	Continue search aft (through the bow) in 10° steps to broad on OPPOSITE bow.
5:50	Slew to 45° abaft beam SAME side.
6:00	Search forward in 10° steps to the bow.
6:40	If contact is not regained, slew aft to beam OPPOSITE side. Begin standard beam-to-beam sonar search.

RELATIVE BEARING PROCEDURE

If you have any doubts as to what relative bearings are and what they do, you'd better reread chapter 3 before you go on with relative bearing procedure.

As you might imagine, the only time relative bearing procedure is different from true bearing procedure is when the ship turns. Suppose you are in a ship that is

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1. Keep gain low to improve pitch discrimination.
2. Do not attempt to determine doppler on one or two pings unless it is marked. Wait for several pings, so that the echo pitch becomes stable.
3. Use long pulse length for easier doppler recognition if the sonar console has a switch for different pulse lengths.
4. If reverberations can be heard, use the first ones as a reference for comparing echo pitch. Disregard the wake echoes, which will be at varying pitches.
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The first rule is to SEARCH FROM AFT FORWARD. The reason for this is illustrated in figure 7–3. In the left-hand illustration you can see the search arc when you begin on the port beam and search forward. Your ship moves through the water while your equipment transmits, and when you search from aft forward you do not cover any area twice.

If you searched from the bow aft to the beam, you would not cover as much ocean territory; you would be searching some areas twice, and there would be a large unsearched area in this pattern. You can see what happens when you search from forward aft by looking at figure 7–3B.

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Here is your second rule: Always search in 10° steps. Although the audio channel is about 15° wide (approximately 7½° on either side of the cursor), the receiving beam width is considered to be only 10° for EFFECTIVE underwater search.

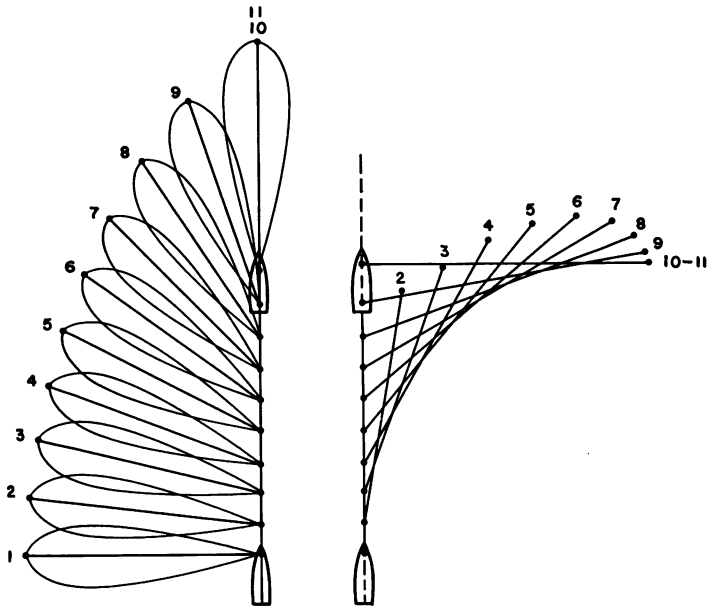

Figure 7–3.—A good search plan covers a large area.

Look at figure 7–4 and you can see that steps smaller than 10° will take too much time.

Your next rule is PING—TRAIN—LISTEN. This means send out a transmission, train to the next bearing, and then listen for an echo. Practice this until you automatically can train forward in 10° steps exactly. Twelve degrees on one step and 7° on the next step is sloppy operating. By practicing the PING—TRAIN—LISTEN routine, you'll be able to search more efficiently. You won't have to think about training the audio cursor when you should be listening.

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You must always send TWO PINGS ON THE BOW. The reason for this runs into a short tale: You will normally search an arc from one beam to the other beam. If you started at one beam and searched forward to the bow, and then continued through the bow down to the other beam,

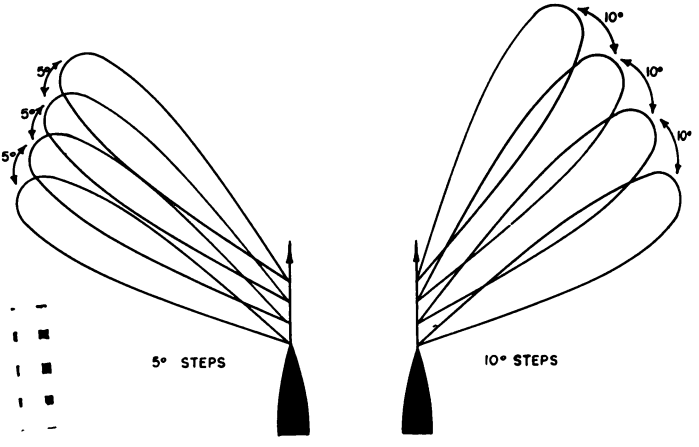

Figure 7–4.—Use exactly 10° steps.

you would be searching the last half of the arc from the bow AFT to the beam. You know from the discussion about figure 7–3B that this is a poor practice. Therefore you divide this large beam-to-beam arc into two parts. You PING—TRAIN—LISTEN from the beam to the bow; and when you get to the bow, you PING TWICE, slew to the other beam, and start forward again.

Suppose there was a submarine directly ahead of you. If you sent out the ping directly ahead and then immediately trained to the beam, you would not be trained at the bearing of the submarine when the echo came in. To make sure you'll get the bearing of the echo, always send out two transmissions on the bow before you train the audio cursor aft. This procedure is illustrated in figure 7–5. You'll appreciate the illustration more if you start with ping No. 1 on the starboard beam and follow the numbers around the arc.

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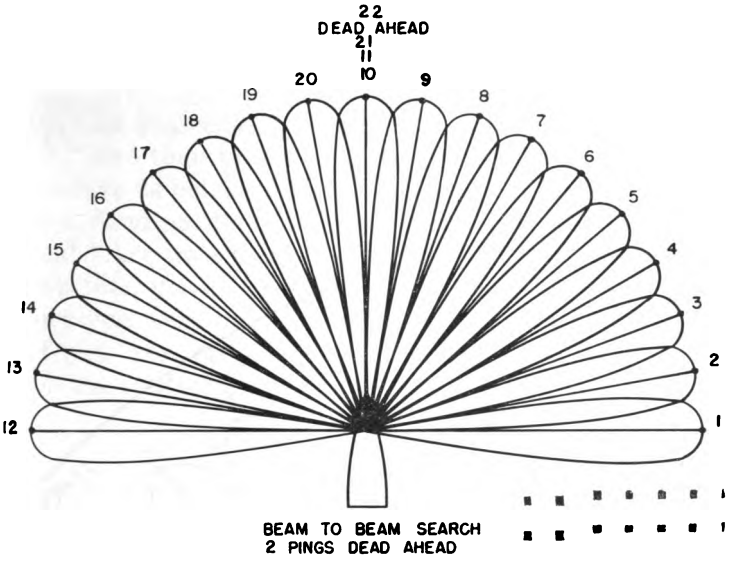

Figure 7–5.—Send two pings on the bow.

There is one exception to this TWO-PINGS-ON-THE-BOW rule. If one of the limits of your search arc lies within 30° of the bow, start at the aftermost limit and search right through the bow, sending out two pings at the end of the arc instead of on the bow. Then repeat this search procedure. The reason for this is that the arc is too small to divide into two areas. It is much more efficient to cover this smaller area in one arc. Look at figure 7–6 for a pictorial explanation of this procedure.

The order to search an arc will be given to you by the A/S or CIC officer. For instance, "Search arc 070° to 350°." (Assume he means true bearings unless he says it's to be relative bearings.)

You reply in exactly the same words to be sure you understood the order. So your answer will be "Search arc 070° to 350°."

Then you begin to search the arc. You search it over and over again with no report unless you hear an echo or receive new instructions.

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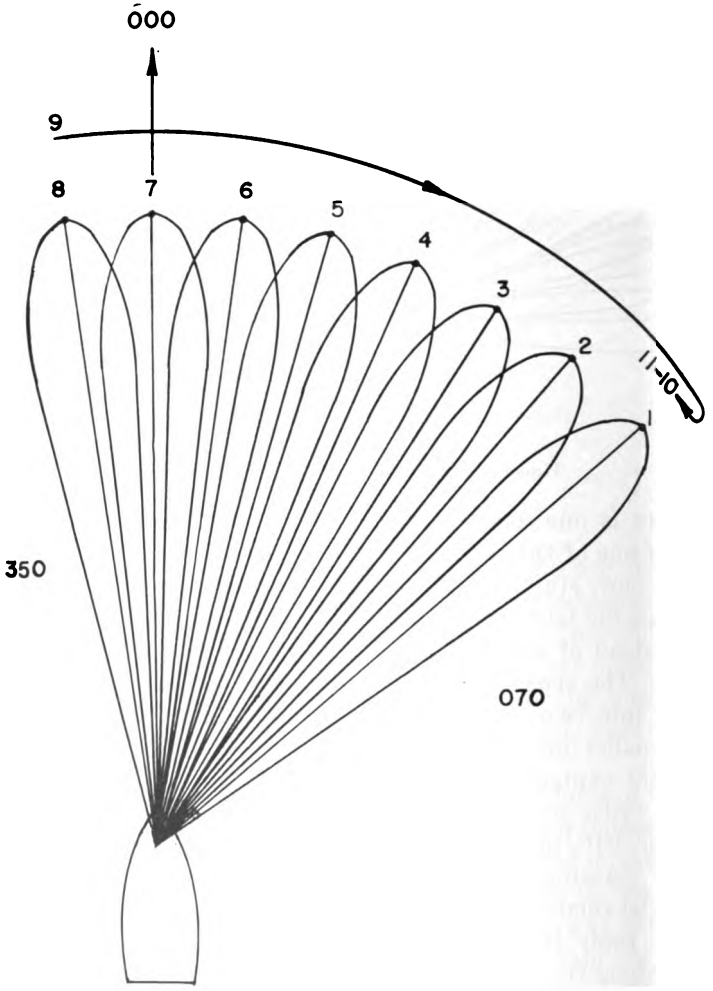

Figure 7–6.—A search arc within 30° of the bow.

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Investigating an Arc

If the presence of a submarine is suspected in a particular area, the order will be "Investigate arc 040° to 010°." In that case, you reply "Investigate arc 040° to 010°," and then investigate the arc once, using the same procedure as before, EXCEPT THAT YOU WILL TRAIN IN 2.5° STEPS. Send out two pings on the forward limit and then repeat "Arc investigated, no echo" if you hear no echoes. After this, you resume the original search arc, starting where you were interrupted.

If you hear an echo while investigating an arc, develop the contact as you would in the search procedure.

CONTACT

When you hear an echo, report it immediately. Say "Sonar contact, bearing—, range—." Always say HUNDRED (not double-oh) when reporting ranges in even hundreds of yards. Thus, a range of 1500 yards is reported: "Range one five hundred." When ranges are not in even hundreds, pronounce each numeral. Thus, a range of 1150 is reported: "Range one one five zero." (In this case say zero, NOT oh.) Some examples are: 1100 yards (one one hundred); 1200 yards (one two hundred), 1350 yards (one three five zero), etc. The only time the sonar OPERATOR gives the range is at this first contact. Ranges are reported by the RANGE RECORDER operator thereafter.

Ping—Listen—Train

Once you establish contact, there is an important change to make. Instead of training the audio cursor when the signal is sent out, you train it after the echo comes in but before the next ping goes out. In this way, you are trained directly at the submarine as the echo comes back. So the routine at contact is ping, listen for the echo, and when the echo comes in, train to the next position. Instead of PING—TRAIN—LISTEN as you did while searching, you now PING—LISTEN—TRAIN.

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After you report the sonar contact, you must make a preliminary determination of the source of the contact. The final decision will not be yours, for accurate classification of a target depends on many factors.

After you report the contact, the OOD checks the bearing visually and the CIC checks it on radar to see if there is a surface ship or school of fish on the bearing and range you called out. The report will be either "bearing foul" or "bearing clear." If the bearing is foul, resume the search procedure. If the bearing is clear, continue to develop the contact so you can help classify the target you have detected. At this time you should expect a change of course toward the bearing you have reported.

How To Classify the Contact

You will start by training 5° aft of the original contact bearing and listening for the echo. If an echo comes back, again train 5° toward the stern. Keep doing this until you are off the target, that is, until no echo comes back. As soon as this happens, ping—listen—train back toward the bow in 2.5° steps. As soon as you hear the echo again, report this bearing as "Right (left) cut....." Now train across the target in 5° steps until you go off the other end of the target, that is, until there is no echo. Then train back onto the target in 2.5° steps until you hear the echo again. Report this bearing as "Left (right) cut....." Then bisect the pip with the cursor and track smoothly. Figure 7–7 will give you a clear picture of a left and a right cut.

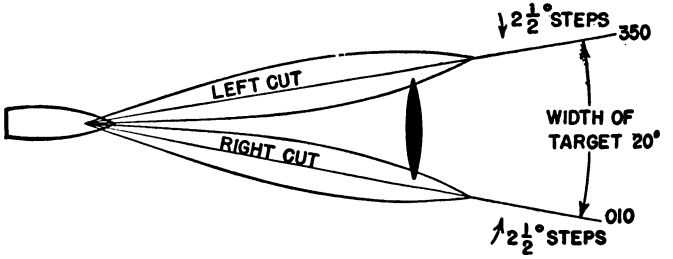

Figure 7–7.—Make your cuts accurate.

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A right cut is the bearing on which you first hear the echo when you train the audio cursor back on the right end of the target. The left cut is the bearing on which you first hear the echo when you train back on the left end of the target. The distance between these two bearings is the target width. You report this as "Target width,..... degrees."

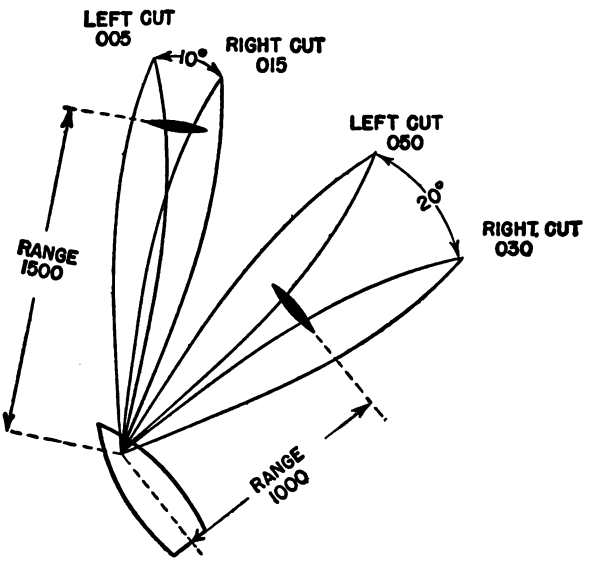

Figure 7–8.—A wake would be much wider.

The width of the target is an important aid in classifying the echo. If the target is a submarine, it will have a fairly narrow width at long ranges. With a shallow submarine this width may be only 2° or 3° at a range of 2000 yards, or it may be as much as 20° at a range of 1000 yards. Look at figure 7–8 and you can see that as the range becomes shorter, the target width becomes greater.

EXCEPTION: With a very deep submarine, the target width does not widen as much at short range as it does with a shallow submarine. A deep submarine is caught

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only by the narrow bottom of the sound beam; a shallow submarine is up in the wide middle of the beam.

After you have reported target width, you must report the doppler. You already know how important doppler is in classifying the target. As soon as you report doppler, report whether the echo is sharp or mushy. If it seems to be clear on one cut and mushy on the other, report that too. The bow cut of a submarine should be clear and sharp, while the stern cut will be mushy because it is at the stern end that you hear the wake echo. So report the side of the target where wake is encountered, and the side of the target where the echo strength drops off sharply.

You can also send out a pair of short signals—di-dit—with the hand key and listen for the echo. If the echo comes back from a good reflecting surface, it will sound like the signal you sent out—di-dit. If it comes back from a poor target, the echo will not have that characteristic sound. This may help you to classify your contact.

Four Classifications

Classification of a target is a command function. This means that the commanding officer ultimately decides whether the contact you have is a submarine. His decision will be based on information supplied by your sonar set, the sonar team, CIC, surface lookouts, and all other members of the antisubmarine team. In all, there are four classifications for underwater targets, and you should understand what you are expected to contribute before accurate classification can be made.

The first classification is POSITIVE SUBMARINE, and the primary source of information is not sonar. A positive submarine is a surfaced submarine, submerged submarine, periscope, or snorkel sighted and identified by personnel competent to recognize positively such objects. Of course, range and bearing by sonar would add further confirmation.

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A POSSIBLE SUBMARINE is one in which a sonar, radar, ECM sonobuoy, or MAD contact is investigated or tracked without confirming all of the characteristics listed for PROBABLE SUBMARINE, but which is suspected to be of submarine origin by competent personnel; or, surface flares, blinker lights, tracer lights, and similar indications which are thoroughly investigated and do not lead to submarine sighting or sonar contact but are suspected to be of submarine origin by competent personnel.

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The table on page 220 is a quick review of what you say and do when you make sonar contact.

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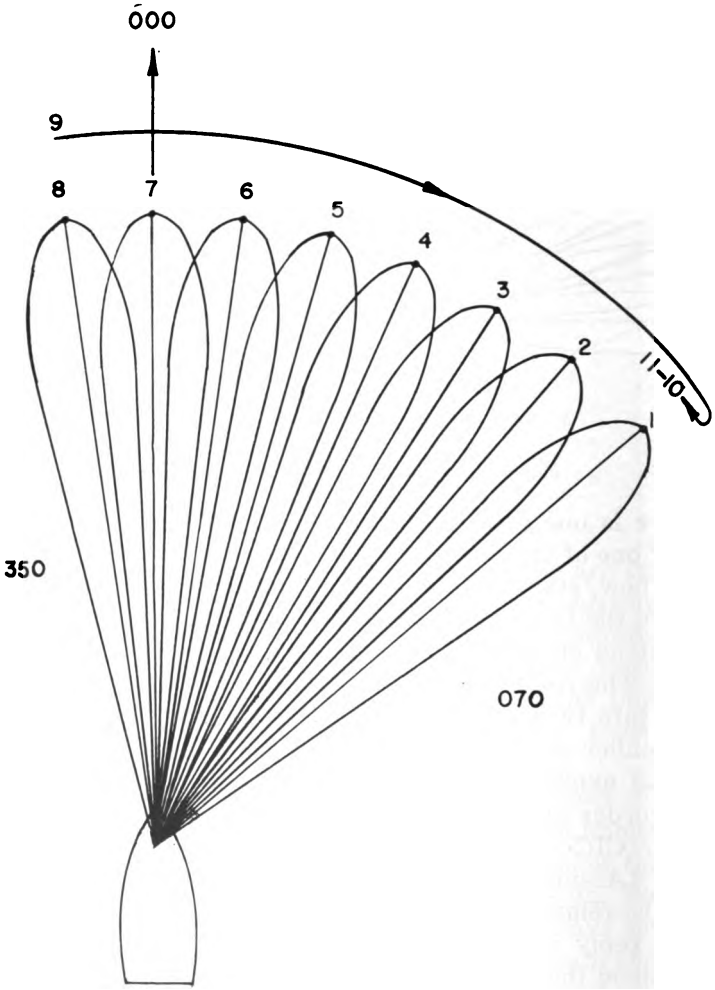

Figure 7–6.—A search arc within 30° of the bow.

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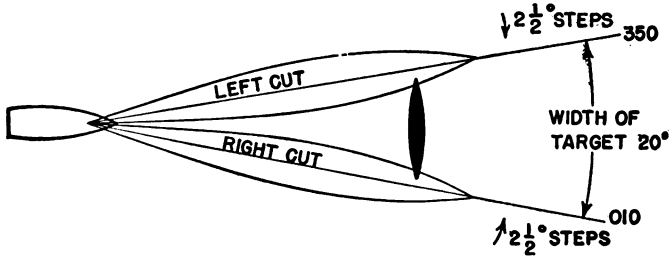

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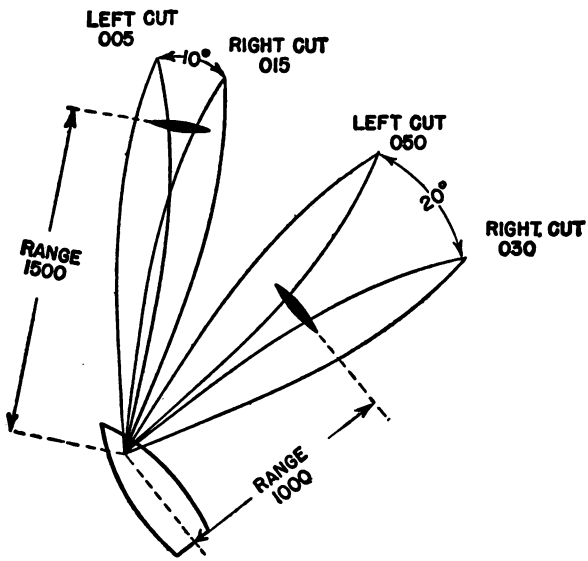

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The table on page 220 is a quick review of what you say and do when you make sonar contact.

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REMEMBER TO PING—LISTEN—TRAIN AS SOON AS YOU MAKE CONTACT!

What you say	What you do
"Sonar contact, bearing_____, range_____." (Conn reports "Bearing clear.")	Train aft in 5° steps until off the target. Then train back in 2.5° steps to get the after cut.
"Right / Left cut_____."	Using 5° steps, train forward across the target and get the other cut.
"Left cut_____." "Right"	You obtain this cut by going off the target and coming back on again in 2.5° steps.
"Target width,_____degrees."	You get the target width by determining the difference between the two cuts.
"Doppler (low, high)," or "No doppler."	Listen to the difference in pitch between reverberation and echo.
"Sharp / Mushy echo"	Determine the quality of the echo—sharp, mushy, loud, soft, and so on.
"Wake on left / right cut."	Determine side of target where wake is encountered.
"Positive sub / "Probable sub / "Possible sub / "Nonsub echo."	Finally classify the nature of the echo.

the contact was lost, you must regain it as soon as possible. The lost contact procedure will enable you to do this.

There are two types of lost contact—lost contact at long range and lost contact at short range. Your actions at the console will be different with each of these types.

Lost Contact at Long Range

First, let's consider lost contact at long range.

Suppose you have made a contact and are in the process of classifying it. Suddenly no echo comes back from the bearing where you think the target should be.

AFTER YOU HAVE SENT OUT FOUR OR FIVE PINGS, AND

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THERE IS STILL NO ECHO, REPORT "No echoes, last bearing ——." Make sure that you report this as soon as you have sent out four or five pings with no submarine echoes.

You should remember on which bearing you heard the last GOOD echo. Immediately after reporting "No echoes," train to the bearing 20° aft of the last good bearing you had before losing the echoes. Search forward from this point in 10° steps. Use the ping—train—listen search procedure until you are at a point 20° forward of that last good bearing. Thus you have searched a total arc of 40°.

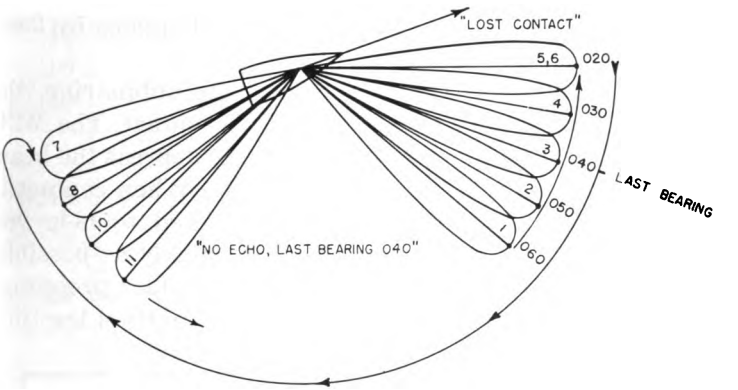

Figure 7–9.—Don't hesitate to report, "No echoes."

If you still have not regained contact, report "Lost contact." Then, the A/S or CIC officer should give you a new arc to search. But until he is able to get a new arc from the plotting team, you must train the audio cursor immediately to the stern or to the forward limit of the baffle plate and begin searching forward on the side on which you lost contact. Search up to dead ahead, using 10° steps and, of course, you will ping—train—listen. The lost contact procedure for long range is illustrated in figure 7–9.

Here, in brief, are the things you will do when you lose contact at long range:

1. After four or five pings without echoes, you will report "No echoes, last bearing——."

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2. Search an arc from 20° aft to 20° forward of the last bearing on which you had contact. Transmit twice on the forward limit.
3. If you do not regain contact, report "Lost contact."
4. Go immediately to the stern, or baffle, and search (10° steps) to dead ahead on the side on which contact was lost.

Lost Contact at Short Range

You will lose contact at short range when the submarine begins to pass under—and therefore out of range of—your sound beam. You can see how this happens by looking at figure 7–10.

You can also see that the deeper the submarine, the longer the range at which you will lose contact. The MCC feature in scanning sonar permits you to depress the beam and thus hold contact to shorter ranges. When contact is lost, you must follow procedures designed to help you regain contact with the submarine as quickly as possible. Here is one type of single ship regain contact procedure for use after depth charge attacks. CIC controls the time

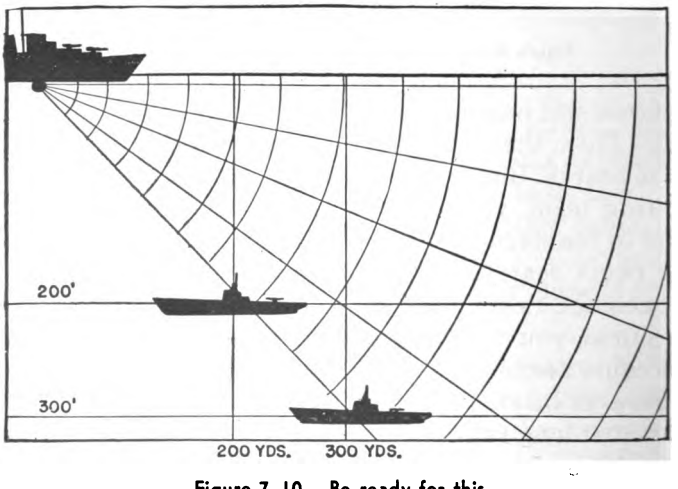

Figure 7–10.—Be ready for this.

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and provides you with necessary search arcs. In the step-by-step procedure below, the ship makes both turns in the same direction, and all search arcs are given in true bearings.

TIME	PROCEDURE
00	Center charge dropped.
20	SHIP COMMENCES TURN
40	Set cursor for fixed search 45° abaft beam on side to which ship is turning.
1:20	Commence search forward in 10° steps to broad on bow.
1:40	Search aft in 10° steps to 45° abaft beam.
2:10	Search forward in 10° steps to bow.
2:40	Slew cursor to 45° abaft beam on same side to which ship is turning. Search forward in 10° steps to bow.
3:10	Again slew cursor to 45° abaft beam on same side. Search forward in 10° steps to broad on bow.
3:40	SHIP COMMENCES NEXT TURN.
4:00	Slew to 45° abaft beam on OPPOSITE side. Search forward in 10° steps to bow.
5:00	Continue search aft (through the bow) in 10° steps to broad on OPPOSITE bow.
5:50	Slew to 45° abaft beam SAME side.
6:00	Search forward in 10° steps to the bow.
6:40	If contact is not regained, slew aft to beam OPPOSITE side. Begin standard beam-to-beam sonar search.

RELATIVE BEARING PROCEDURE

If you have any doubts as to what relative bearings are and what they do, you'd better reread chapter 3 before you go on with relative bearing procedure.

As you might imagine, the only time relative bearing procedure is different from true bearing procedure is when the ship turns. Suppose you are in a ship that is

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steering on course 000°, and you make a contact at 090° true. After your ship turns and is heading for the target, the true bearings will still be about 090°.

But suppose the gyro in your console is out, and you have to work on relative bearings alone. You make this same sonar contact at 090° relative. But after your ship turns and is heading at the contact, the relative bearing has changed from 090° to 000°. You can see this change in bearing in figure 7–11.

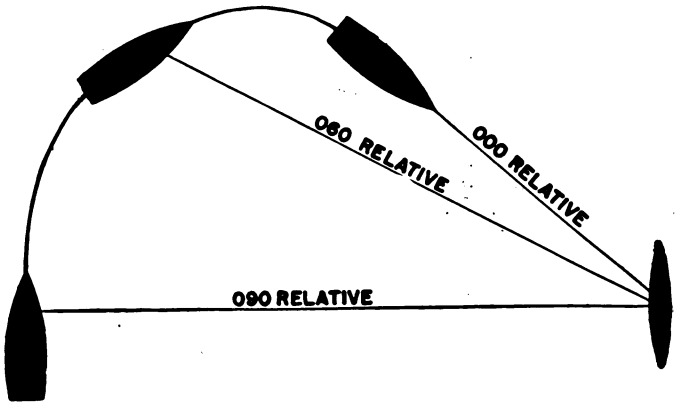

Figure 7–11.—Relative bearings change rapidly in a turn.

The big problem in relative bearing contact procedure is to hold contact during a major change in course.

To hold contact with relative bearings, you'll have to know when your ship is going to change course, in what direction it is going to turn, how many degrees will be involved in the turn, and when the change in course will end, that is, when the ship will steady on the new course. The conning officer will keep you informed of all the course changes—via the A/S officer and your sonar supervisor.

Suppose you pick up a contact at 090° relative. First you will get the after cut, the target width, doppler, and so forth. Then continue as in true bearing procedure. But

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when conn says, "Coming right 90°," you'll have to make a few changes in the usual routine.

If you leave the cursor trained at 090° R when your ship changes course, you will be trained at a position 90° away from the submarine when the ship steadies on the new course. As the ship swings around, the actual bearing will change rapidly from 090° R and so on, until finally it is 000° R. If you try to get cuts as the ship swings, you will lose the submarine because its relative bearing is moving too rapidly.

A couple of rules have been established to enable you to hold contact during a turn. Follow the procedure and you won't have too much trouble. Remember: In relative bearing procedure, all bearings reported are RELATIVE bearings.

A Turn with Relative Bearings

As soon as conn tells you that he is going to make a turn to head for the submarine, train your cursor 20° forward of the bearing of the target, and leave the cursor on that bearing. If echo pip is visible on scope, follow pip with cursor. If there is no pip, listen for an echo, and when it comes in, report "Bearing_____" and then train 20° forward again. Leave the cursor there and listen for the echo. Each time the echo comes back, report the bearing, and train forward 20°. Continue doing this until the target is ahead of you, or until the conning officer announces "Steady on new course." Track the target. In the rare instance where you have no visual indication, take cuts as you would in searchlight procedure.

If, during any phase of this course change, you do not hear or see an echo for four successive pings, report "No echoes, last bearing_____." Then ping—train—listen toward the stern in 10° steps. Do this until you have searched an arc of 40° which will be 20° abaft your last bearing. (Look at fig. 7–12.) If you still have no echo, report "Lost contact." CIC will give you a new search

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arc at this time. If no search arc is received, train dead ahead (000° R). Wait with the cursor on 000° R, being especially alert for video and audio echoes, until you hear conn report "Steady on new course." Then search the arc of 330° R to 030° R. Start this search on the side to which your ship originally turned; that is, if you came right,

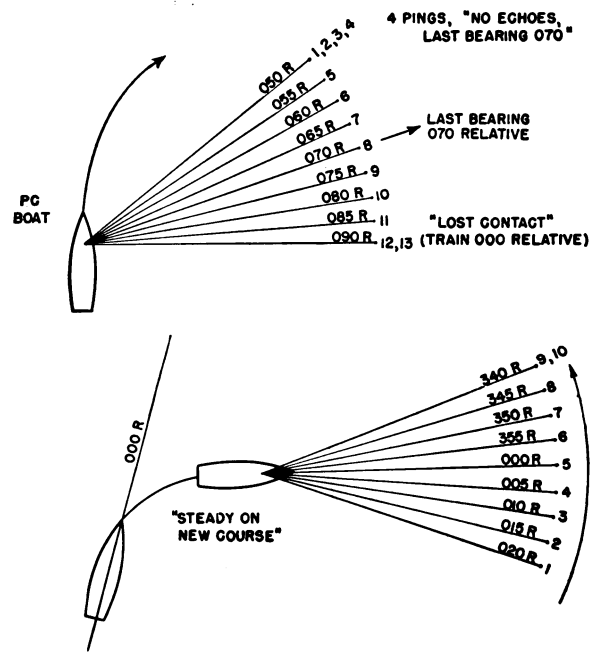

Figure 7–12.—You must do this smartly.

start the search at 030° R and search forward through the bow to 330° R, paying particular attention to the video presentation.

NOTE.—If you hear "Steady on new course" at any time during the course change when you have lost contact or reported no echoes, immediately search the arc from 330° R to 030° R.

These steps of 20° in the turn during lost contact are for a ship with a small turning circle such as a PC. If you are on a ship which turns more slowly, such as a DD, train

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forward in 10° STEPS when the ship begins to turn, instead of 20° steps. If there is no echo, start aft in 2.5° STEPS and search to a position only 10° abaft your last good bearing. If you use a 20° step on a slow-turning ship, you will jump too far ahead of the submarine. That's important. Remember it.

You must understand this relative bearing procedure so that you can carry it out without the slightest hesitation. If you have to stop to think about what you should do next, you may easily be too late and lose contact.

If you make a contact in a position—say, slightly on the bow, where it is not necessary to make more than a 20° turn—just continue to cross the target. This relative bearing procedure is used only when you must change course more than 20° to head for the target.

If conn decides to turn more than 20° AWAY FROM the contact to open the range, use this same procedure but in reverse. That is, train 20° abaft your last good bearing at the start of the turn, wait for the echo, report, and train aft 20° again, paying particular attention to the video presentation. Continue doing this until you are told that you are steady on the new course. If you hear no echo on a bearing, you will train forward in 10° steps until you have searched an arc of 40°. If you still have no echoes, request a new search arc.

The only trick for the rest of the run is knowing what to expect the bearings to do after a small course change. IF THE SHIP TURNS RIGHT, THE RELATIVE BEARING WILL MOVE LEFT. IF THE SHIP TURNS LEFT, THE RELATIVE BEARING WILL DRAW TO THE RIGHT. Remember this. Bisect the echo pip with the cursor and track smoothly.

Search—Relative Bearing Procedure

In the search there is only one change from true bearing procedure. Here it is: When the ship changes course by more than 40° while you are searching, train to 000° relative and wait until the ship is steady on the new

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course. Then begin to search from the after limit of your search arc. Search from aft forward on the side toward which you turned. If you were searching 090° R to 270° R, on a course of 000°, and your ship came right to course 060°, you would begin the search at 090° R after the ship had steadied on the new course.

LISTENING

You won't listen very often for the noises of submarine screws. Most of the time you'll be echo ranging. You don't listen because your own ship, steaming along at 15 knots, makes so much noise that it blots out the low sounds from a submarine going 3 knots. The submarine will hear you perfectly. But you are making so much noise that you won't hear it.

Of course, the closer the submarine is to you the more likely you are to hear any noise it is making. But under ordinary circumstances, an escort ship wastes time when listening because it has to reduce its speed to hear the noises. So echo ranging is the order of the day.

It's quite possible that you will hear screw noises while listening for the echo when you are echo ranging. This is particularly true at the end of the run. But you can also hear your own screw noises, so be careful of screw noises that you hear at 180° relative.

If you hear hydrophone effect (as these screw noises are called), be sure to report it. And be particularly alert for the noise of a torpedo. Listen to recordings of torpedo noises so you will be able to recognize them. A quick, accurate report of the bearing of a torpedo can save your ship.

You may be given an order to listen and not echo range. The order will be "Make a listening sweep from..... degrees to.....degrees." When you hear this, stop echo ranging and train smoothly at the rate of 12° per second from the aft end of the search arc forward and back again. If you hear nothing, report "Arc swept by listen-

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ing, no results." Then echo range on the previous search plan. If you DO hear a noise report the bearing and sweep smoothly back and forth across it, reporting the bearing where you hear the loudest noise.

WORKING WITH CUTS

Cuts are always used in searchlight sonar, except when you are ordered to use the bearing deviation indicator (BDI). Then you will use cuts occasionally. The searchlight beam is so wide that you can get an echo from any bearing over a wide arc. You would have no way of knowing which bearing is the true bearing of the submarine. So you determine the two end bearings of the target, and conn computes center bearing, which is the middle of the target.

By using the BDI you can find the center of the target accurately WITHOUT using cuts. To do this, you must know how to use the BDI. A discussion of BDI comes later in this chapter.

Cuts Are Important

After you have made a contact and classified the target, the most important thing you have to do is give as many cuts as you can, as accurately as you can. The accuracy of the cuts depends on how carefully you come back on the target after you have gone off one end of it.

You MUST come back on in small steps of 2.5°. If you come back in larger steps, you may move the sound beam from a position entirely off the target to a position in the middle of the target IN ONE STEP. And you would be reporting the bearing on the middle of the target as a cut. The cut should be the bearing on the edge of the target.

When you are getting the stern cut of the submarine, you must listen for the doppler echo of the submarine and not be led off by the loud no-doppler echo of the wake. As soon as you leave the doppler echo of the submarine and go onto the no-doppler echo of the wake, train back im-

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mediately in 2.5° steps until you again hear the doppler echo. It is this bearing that you should report as the cut. It is much easier to obtain accurate cuts from the bow end of the submarine. On the bow end, the echo drops from a weak but clear echo to no echo at all. So it's a simple matter to come back on the bow in 2.5° steps and call the first good echo the cut.

The speed with which you give cuts depends on how many pings you spend crossing the target and how many pings you spend off either end. You should gage your steps so that you have three pings on the target and one ping off either end. That is, ping once off the target, once on the cut, once in the middle of the target, once on the other cut, and then once off the other end. Figure 7–13 illustrates this rule of three pings on the target and two off.

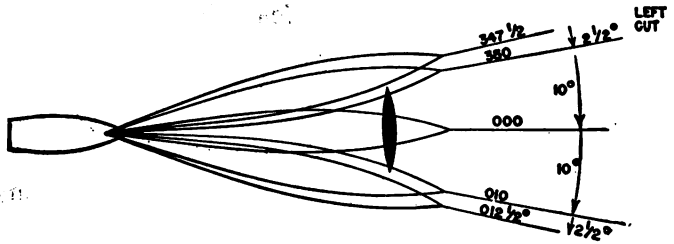

Figure 7–13.—Crossing the target.

Go off the target in a step of the right size, so that when you come back 2.5° you will get the echo from the end of the target.

Keep the gain low during an attack. The sound beam in the water is in the shape of a lobe and the edges of this lobe return weak echoes. When you turn the gain low, you cut out these weak echoes, and hear echoes coming from near the center of the beam only. You can see the advantage of this if you will look at figure 7–14.

With the gain low, you can cross the target more easily and in a shorter time. Furthermore, the bearings you report will be more accurate.

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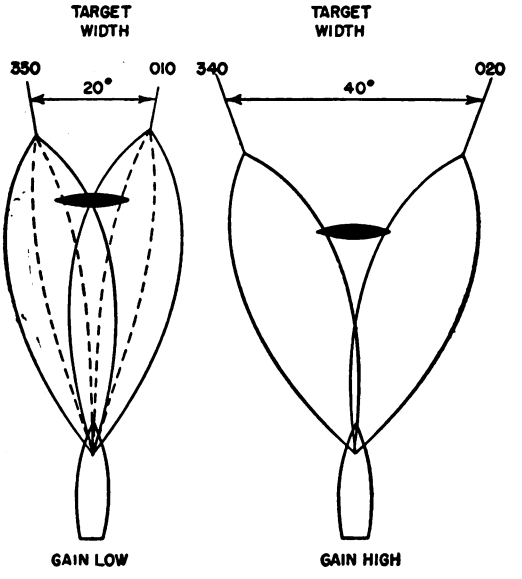

Figure 7–14.—During attack, keep the gain low.

When you turn the gain high or low, you are not changing the size of the sound beam in the water. You are simply allowing the receiver to be particular about what part of the sound beam it wishes to "hear." When the gain is low, the receiver "listens to" the center of the beam, not bothering with the edges. To you, sitting at the console, it seems as if the beam had become narrow with the low gain.

Bow Cuts Only

If the A/S officer needs rapid information about the leading cut—which is the bow cut—he may give the order "Right (or left) cuts only." In this situation, you get the required cut and then place two good pings on the target. Train off the target on the same side, and then come back on the target in 2.5° steps to get that cut again. Place two pings on the target and get the leading cut again. Continue doing this until the A/S officer tells you to cross the target.

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Sweeping the Target

When the range closes, the target may get wider. If this happens, you will have a greater distance to cover with your sound beam and the cuts will become farther and farther apart from one another. You'll have to take large steps to get across the target in three pings. As a matter of fact, when the range closes to 300 or 200 yards, you may not be able to get across the target in steps. You will have to SWEEP THE TARGET. Sweeping the target means training across it with one long, smooth, continuous turn of the handwheel.

When you are sweeping the target, train across the target rapidly until you go off one end, BUT SWEEP BACK ONTO THE TARGET MORE SLOWLY TO GET THE CUT. Then sweep rapidly over the target and off the other end, and come back onto the target slowly to get the other cut. Just as you used small steps to get the cuts and large steps to cross the target, you use a slow sweep to get the cuts and a fast sweep to cover the target.

Properly used, this sweeping motion will give you valuable information and enable you to hold contact with the submarine for a longer time at short range. You must expect the bearings to move rapidly down one side of the bearing indicator in the final stage of the attack.

BDI

The BDI must always be on whenever the sonar gear is being used. But you will not use the BDI until the A/S officer orders you to do so. You will never be told to shift to BDI until your ship has headed toward the target, until the target is classified, and until the BDI is furnishing you with good right and left deflections.

Usually these conditions will not all be met until the range has shortened to about 1000 yards. Sometimes it may be possible to shift before this range has been reached.

The BDI may aid you even when you are using the cut procedure. It can give you a rough visual picture of the

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echoes you are hearing. But remember—deflections can come from objects other than submarines. When you are turning toward the target, the BDI may aid you in holding contacts. But until you are ordered to shift to BDI, USE CUTS.

As soon as you shift to BDI, report ONLY center bearings as read from the BDI indications. Don't stay on center bearing, but train a few degrees first to one side of center and then to the other side, getting a good deflection on either side before coming back to center. Train left, get a good deflection, come back to center, and report the center bearing. Train right, get a good deflection, come back to center, and report the center bearing. Do this until you know in which direction the submarine is moving, then train only in that direction. If the bearing is moving left, train to the left, get a good deflection, come back to center, report the bearing, and train to the left again.

When you train toward the leading edge of the target, make sure that you get ahead of the center before you come back again. By training ahead of the target center, you will stay away from the wake, and therefore lessen your chances of falling back into the wake. If you are getting TWO-SIDED SPLITS instead of the brightening alone, as you often will with beam targets, take an occasional bow cut to make sure you are not being drawn into the wake.

Use very small steps of about 1°. Almost every new operator uses steps that are too large when first using the BDI. The center bearing you report is accurate to about 2° or 3°, so take your time! Train carefully and make the bearings as exact as possible.

If you have any doubt about the reliability of the bearings you are getting from the BDI, shift back to cuts. Don't hesitate! It's more important for you to hold the target than to give accurate bearings on something that is not a submarine.

After the order to launch throwing weapons is given, or when you lose contact because of the short range in a D/C

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attack, shift back to the cut method while you open the range for a reattack.

Remember, BDI center bearings are VERY ACCURATE. You can get plenty of them without rushing, so take your time. Be deliberate and accurate. And most important of all, LISTEN to the returning echoes. The visual indications are only an aid to your ear.

SUMMARY

Make all your reports in a loud, clear voice, and always use standard phraseology. Whatever communication setup you have—sound-powered telephones, MC circuits, or voice tubes—standard reports require less circuit time to transmit the information other stations need, and their use holds down the noise level.

MEMORIZE THIS: It's PING—TRAIN—LISTEN when you are searching, and PING—LISTEN—TRAIN—as soon as you make contact.

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QUIZ

1. What is the appearance of torpedo noises on the sonarscope?
2. How do you get accurate bearings from noise spokes on the sonarscope?
3. What do you do when an echo pip remains on the scope?
4. Of what value is the MCC switch in assisting in classifying a target?
5. Why is it important to decrease your gain during an attack?
6. What is the main reason doppler is difficult to determine with scanning sonar?
7. Which station controls the time and provides search arcs in single ship D/C attack, regain contact procedure?
8. What is the procedure when there is a casualty to the gyro?
9. What is meant by the term SEARCH?
10. Normally, how large a step does the operator use for searching?
11. What is the correct order for training the gear and listening for the returning echo?
12. When you are ordered to investigate an arc, how many degrees of train are used for search transmission?
13. What is the proper phraseology for reporting a contact?
14. What is a cut?
15. When developing cuts, how fast should you cross the target?
16. After reporting NO ECHOES, to what bearing does the operator train?
17. On which can you expect to lose contact sooner, a deep submarine or a shallow one?

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CHAPTER 8

TACTICAL RANGE RECORDER

WHAT IT CAN DO

The tactical range recorder (TRR) is capable of doing a great amount of work. It records time and range and it puts in writing the echo sounds your ears hear. It can be one of the most important pieces of equipment, next to the stack, if the man operating it knows what he's doing and DOES IT WELL. A good operator can get extremely valuable information from the range recorder under the worst sound conditions. It's all a matter of knowing what your equipment can do, and then operating it to the best of your ability.

The recorder, illustrated in figure 8–1, will give you four vital pieces of information. It will give you the RANGE—the distance of the submarine from your ship. It tells you the RANGE RATE—the speed at which you are approaching the target. From the echo traces on the recorder, you can find out the approximate TARGET ASPECT and TARGET DIRECTION. And most important of all, the recorder indicates the time when depth charges should be dropped or when throwing weapons should be launched.

HOW TIME AND RANGE ARE RECORDED

The recorder automatically plots time and range. It will be easier for you to understand how it does this if you first know about the simple time-range plot.

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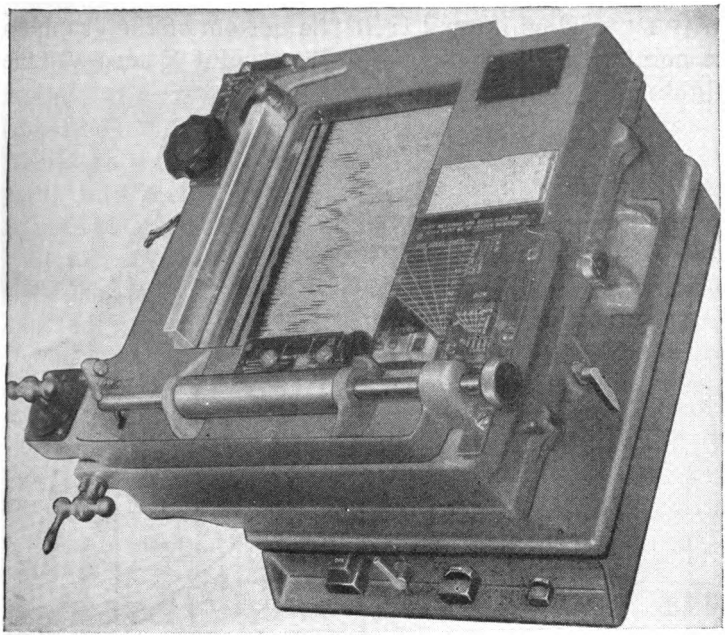

Figure 8–1.—Its value depends on your ability.

Imagine that your ship is passing by a lighthouse, as diagrammed in figure 8–2. At any time when you are approaching the lighthouse, take the range. The first time that you take the range it is plotted and referred to as ZERO time. In this instance, say that the lighthouse is 1400 yards away from you at zero time. One minute later, take the range again. This time you are 1000 yards away, in position B of figure 8–2. And 1 minute later you are in position C, only 700 yards away from the lighthouse. When you pass the target abeam, at position D, another minute has passed and the target is 500 yards away from you. In 1 more minute you are at position E, and the range has opened to 700 yards. If you put these times and ranges on a sheet of graph paper, the result will be a time-range plot, such as the one shown in figure 8–2. It is better to plot ranges against time FROM THE BOTTOM OF THE

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GRAPH UP. Time is read from the bottom of the graph up to point X, and range is read from point X across to the right.

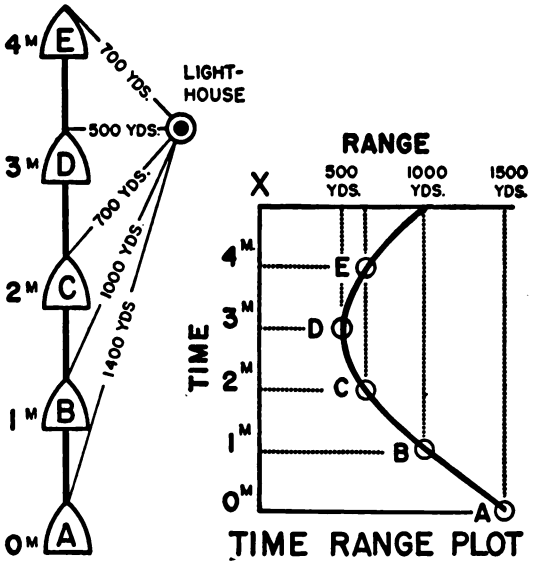

Figure 8–2.—The simple time-range plot.

You can make a time-range plot in the following manner. (Check constantly with figure 8–2.) Plot in point A at zero time—which is always at the bottom of the graph—and 1400 yards. One minute later, take the range again, and plot in point B at 1 minute on the time scale and 1000 yards on the range scale. Plot C 1 minute later, or at 2 minutes on the time scale, and 700 yards on the range scale. Plot D at 3 minutes on the time scale and 500 yards on the range scale. Lastly, plot E at 4 minutes on the time scale and 700 yards on the range scale.

Now join all the points with a smooth line, and you have a time-range plot of the ship passing the lighthouse. You can read the range for any particular time and you also have a record of what time it was when the ship was at any particular range.

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Consider this plot a little more closely. In the minute between C and D, you have closed the range 200 yards. The curve from C to D goes up almost straight. In the minute from A to B, you closed the range just twice as much, 400 yards, and the slope of the curve is at a different angle from the slope between C and D. The curve is not as steep.

By measuring the steepness of this curve, you can tell how fast your ship is closing the range between it and the lighthouse. If the curved line is nearly up and down, as at D, you aren't getting any closer to the target. If it is not as steep, as at B, you are getting closer to the target—closing the range at a faster rate.

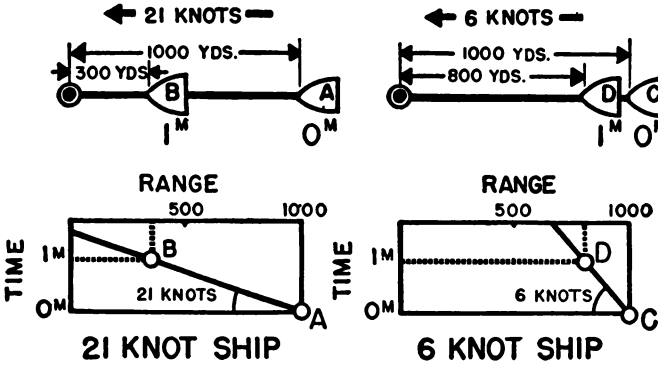

Figure 8–3.—Slope of the line indicates range rate.

In figure 8–3, you can see the difference between a time-range plot for a 21-knot ship and a time-range plot for a 6-knot ship, both of them approaching a buoy 1000 yards away.

Note the difference in the slope of the line in each plot. The faster the ship closes the range, the smaller the angle becomes, and the more the line slopes to a horizontal position.

The speed at which the ship closes the range is known as the range rate. There are two examples of range rate

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in figure 8–3. One is a 21-knot range rate and the other is a 6-knot range rate. In the 21-knot range rate, the ship closes the range at 700 yards a minute. In the 6-knot range rate, the ship closes 200 yards in the same length of time.

ENERGIZING THE RECORDER

When sonar contact is established, the tactical range recorder is energized by turning the main switch to the ON position. From that moment, the sonar equipment is keyed by the recorder at a selected range scale, either 0–3750 yards (long) or 0–1500 yards (short). The recorder operator determines the range scale after hearing the console operator's first bearing and range report. Although the sonar console continues to function, the rate of keying (or transmitting) is controlled by the recorder.

Part of the returning energy is sent to the loudspeaker and part is sent to the recorder. The recorder puts on tape what the loudspeaker puts in sound, and thus enables you to see what you hear. On the upper side of the recorder there is a stylus, which you can see in figure 8–4.

The stylus is pulled across the special recorder tape by electrical energy. Each part of the signal from the echo-ranging stack—ping, reverberations, echo—sets up an electrical current which passes from the stylus through the recorder tape to the metal beneath, producing a chem-

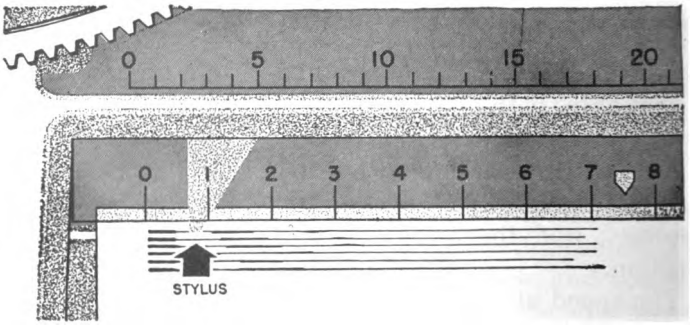

Figure 8–4.—The stylus marks the tape.

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ical reaction in the specially treated tape. As a result of this action, dark lines are left on the recorder tape. These markings are called TRACES and by interpreting them, you can report a great deal of valuable information.

THE RECORDER AS A TIME-RANGE PLOT

The ping (transmission) is marked on the left edge of the recorder plot. It may be either a short dash or a blank space between a dot and a line, depending on where the recorder is hooked into the circuit. These two types of transmission traces are shown in figure 8–5.

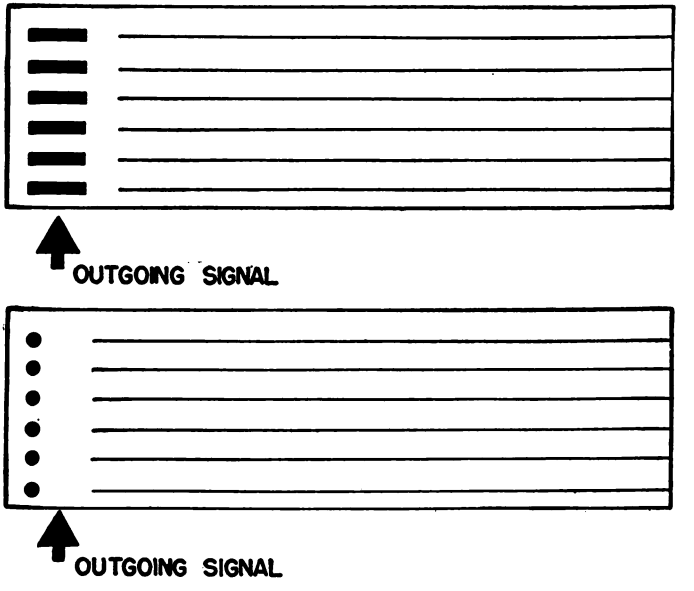

Figure 8–5.—Both traces are of the outgoing transmission.

The next traces made on the recorder plot are of reverberations, and these appear as an interrupted line across the tape. You must learn to distinguish between the echo trace and other traces and by interpreting these, you can discover the target aspect. You'll learn how to do

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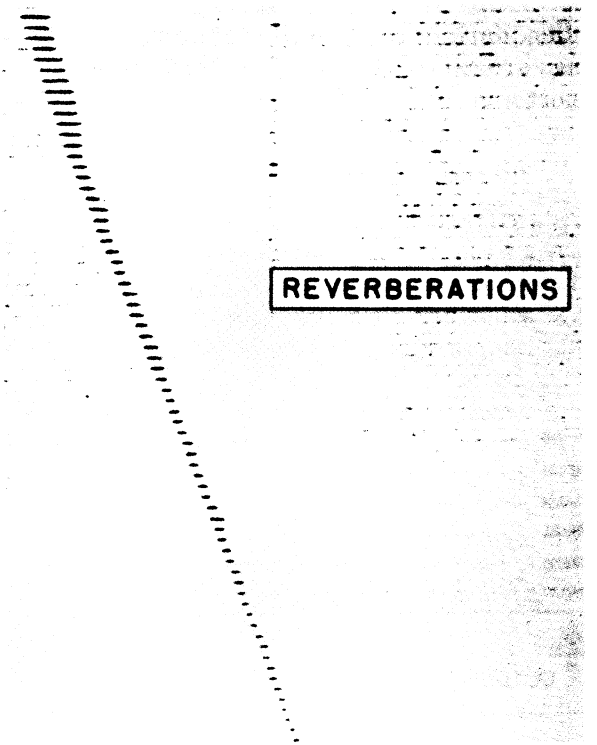

Figure 8–6.—Echoes and reverberations print.

this in chapter 10. Reverberation and echo traces are illustrated in figure 8–6.

The recorder actually gives you a plot of time against range. The plot is made like the time-range plot except that the recorder does all the mechanical work for you.

The stylus begins its movement across the tape when the transmission goes out into the water, moves at a steady speed across the tape, and snaps back to the left side in time for the next transmission. It does this over and over again. THE RANGE IS THE DISTANCE FROM THE LEFT SIDE TO THE ECHO TRACE.

The time element is recorded because the tape moves

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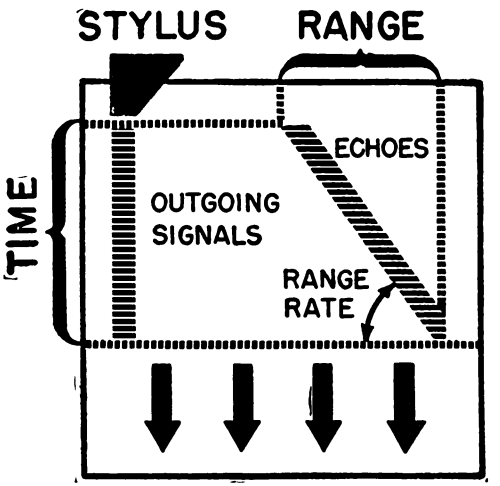

Figure 8–7.—The time-range plot of the recorder.

down at a constant speed. This causes the traces on the tape to be spaced apart on a time scale. The time-range plot kept by the recorder is shown in figure 8–7.

THE LONG AND SHORT OF IT

There are short- and long-range scales on the recorder for reading the range. These are located near the top on the upper surface of the recorder. The left sides of the range scales are shown in figure 8–4. The upper one is used with long-scale keying. Ranges from zero to 3700 yards may be read on this scale, each division representing 100 yards. The lower one is used with short-scale keying, and ranges from zero to 1500 yards may be read. Again, each division represents 100 yards.

The switch for controlling the range scale is called the GEAR CHANGE LEVER and is shown in figure 8–8. It is located on the right side of the recorder. You can set the gear change lever in any of three positions—NEUTRAL, LONG-SCALE KEYING, or SHORT-SCALE KEYING. When the main switch is at ON and the gear change lever is turned as far as it will go in a counterclockwise direction, the

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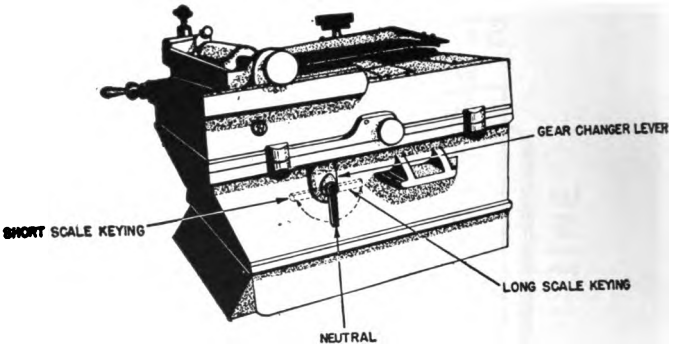

Figure 8–8.—The gear change lever.

speed of the stylus will be SLOW, the recorder tape will move down more slowly, and the LONG-SCALE keying will be in effect.

When the gear change lever is turned as far as it will go in a clockwise direction, the speed of the stylus will be FAST—that is, SHORT-SCALE keying will be in operation. The stylus will move across the tape 2½ times faster and the tape will move down 2½ times more rapidly. Read ranges from the scale which corresponds with the position of the gear change lever. If the lever is at long-scale keying, read ranges from the upper scale. If you have it in the short-scale position, read ranges from the lower scale.

When the gear change lever is shifted to neutral—halfway between the long- and short-scale keying positions—the tape and stylus do not move and no signal is transmitted.

The flyback, and flyback pointer, which you can see in the undress picture in figure 8–9, are important elements of the recorder. The stylus moves to the right until it reaches the flyback whose position is marked by the flyback pointer. There, an electrical contact releases the stylus, allowing it to spring back to the starting point, where, after a very brief interval, it begins a new excursion.

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VIEW OF STYLUS AND FLYBACK MECHANISM WITH RECORDER COVER CASE OPEN

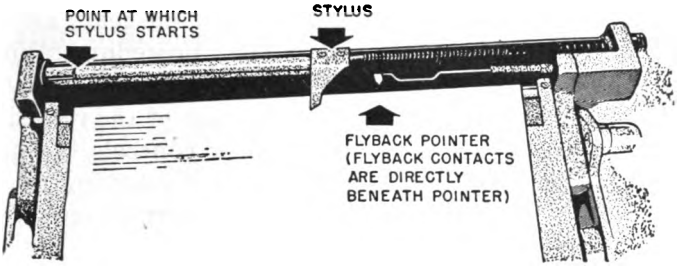

Figure 8–9.—The flyback pointer.

The number of transmissions sent out depends on the flyback position as well as on the position of the gear change lever. If the flyback is moved to the left, transmissions are sent out more often. If it is moved to the right, there is more time between transmissions.

THE CONTROLS

The four controls that you will use constantly are on the front of the recorder. Always keep one hand—usually your right—on or near these controls. They are shown in figure 8–10.

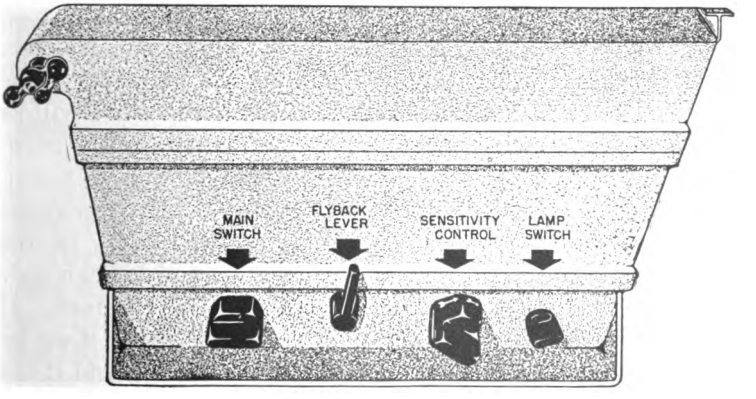

Figure 8–10.—Know your controls well.

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The main switch has four positions, OFF, HEAT, ON, and TEST. When the recorder is not in use, it is turned to OFF. If the temperature is below 35° F. the moist tape of the recorder may freeze, and you must turn the main switch to HEAT, as required by cold weather procedure. When the main switch is at HEAT, a current is passed through heating elements which warm the interior of the recorder. When in the ON position, the recorder controls the keying of the outgoing signal, just as did the keying relays in the console. The ON position is the normal operating position.

The TEST position allows the tape and stylus to move but no trace is printed, and keying of the outgoing signal is still controlled by the console. This position is used for warming up the recorder prior to operation.

Some recorders do not have the HEAT position, and the test position is replaced by STANDBY. On STANDBY, the vacuum tubes are excited and ready for full operation, but neither the stylus nor the tape moves.

The next control is the FLYBACK LEVER and it controls the position of the flyback contacts. Keep your right hand on this control during an attack, and keep the flyback at 1500 yards on short scale and 500 yards beyond the echo on long scale. Don't pull the flyback in at a time when it will hit the oncoming stylus. The two may catch and result in a recorder casualty. Move the flyback in as soon as the stylus has touched it and is on its way back to zero.

The SENSITIVITY CONTROL regulates the printing of the trace. If you turn it lower—to the left—the trace will be lighter. This control does not have any effect on the intensity of the signal you hear from the stack. The gain control on the receiver is the master control, and determines the amount of electrical energy that will come to the recorder. The sensitivity control on the recorder can only LIMIT the signal that is sent to it from the receiver. If the gain is too low on the stack, you can't bring it up by turning the sensitivity control on the recorder. And if the gain is too high on the stack, the sensitivity control may

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The last switch is the LAMP SWITCH. It controls the light which illuminates the recorder traces.

On the right side of the recorder there is a small SNAP SWITCH which turns on the fluorescent light for use in darkness. This lamp makes the traces on the special fluorescent recorder tape stand out clearly under darkened conditions. Another special lamp is used to illuminate the fluorescent markings on the various scales on the face of the recorder.

CUTTING IN THE RECORDER

As you know, the recorder can take over the console's job of timing the keying. The shift from the stack to the recorder must be accomplished without a hitch. If the recorder is not cut in smoothly, there may be a long period when neither the stack nor the recorder is keying, or when both of these units are keying at the same time.

During the search, keep the recorder at the STANDBY position if your unit has this position. If not, keep the main switch off. On any contact—sonar, radar, or visual —the standby operator will turn the main switch to TEST. The type of recorder with a standby switch will be left at STANDBY.

Each attack team will develop its own cutting-in technique by practice. However, here's a method that works well. Upon sonar contact, throw the recorder main switch to TEST, and allow a few seconds for the recorder to warm up. After the console has keyed, turn the main switch to ON and shift the gear change lever to the proper keying scale. Use long scale if the range is over 1300 yards; under 1300, use short scale.

If the recorder has a standby position, you cannot shift the gear change lever until the main switch is ON. Use the

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During an attack on a submarine, you must provide a certain amount of information from the range recorder. You must report ranges, range rates, target aspects, and other details of the sub's movements. The A/S weapons officer (or firing petty officer) will give you the setting for either a depth charge or a throwing attack. As soon as he tells you which type of attack you are going to use, you will make any necessary adjustments to the firing time. While making these adjustments, continue to report all the information. Then, at the appropriate time, you'll call out the time to fire the weapons. After the attack, you will continue to report ranges and target aspects while your ship is being maneuvered to gain position for reattack.

To operate the recorder, you must know about recorder adjustments and recorder procedure. The rest of this chapter is devoted to all the details of these two matters.

READING THE RANGES

Immediately after you cut in the recorder, begin to call the ranges. Read the range from the left edge of the echo trace, except with down doppler, then read range one transmission length in from the right edge of the trace on the proper range scale. Report the range after every bearing, DOVETAILING YOUR REPORTS WITH THE BEARING REPORTS GIVEN BY THE STACK OPERATOR. Usually the recorder operator will call out the range immediately after the sonar operator has reported a bearing. Remember to use standard numeral pronunciation.

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When the range closes down to 200 yards less than the maximum short-range scale (which is 1300 yards on all the latest recorders), you must shift from long scale to short scale. Here's how you do this. Place your right hand on the gear changer lever and your left hand on the flyback control. Just after the stylus hits the flyback, turn both hands clockwise. This will change the keying interval to short-range scale, and it will throw the flyback out to the right edge of the short scale where it will not interfere with the keying. Make sure you move both of these controls together, that is, move the flyback out and shift gears at the same time.

KEEP THE FLYBACK WHERE IT BELONGS!

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When you switch to SHORT-SCALE KEYING, keep the flyback at a range of 1500 yards. Regardless of how close you are to the submarine, never bring the flyback in closer than the 1500-yard range on the short scale. If the flyback is brought in closer than 1500 yards, the submarine may, from the length of the keying interval, be able to estimate the range to your ship.

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The instruments that enable you to read the range rate are shown in figure 8–11.

Look at the plotter bar and the range rate scale. You remember that range rate on a time-range plot is found by noting the slope of the curve. On the recorder you measure this slope by lining up the parallel lines on the plotter bar extension with the slope of the traces on the tape as in figure 8–12. You find out how much the curve slopes in knots by reading the dial marked RANGE RATE SCALE. This scale is calibrated in knots. It works equally well on both long and short scales.

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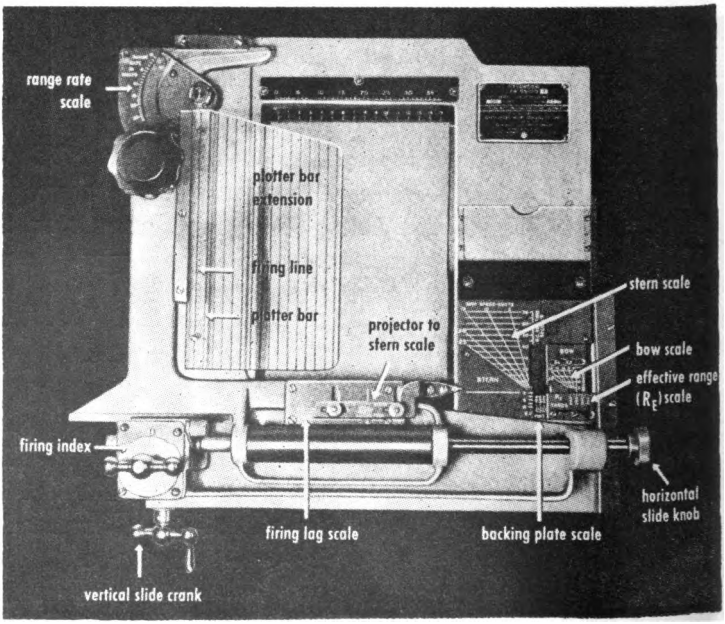

Figure 8–11.—Learn the names of the parts.

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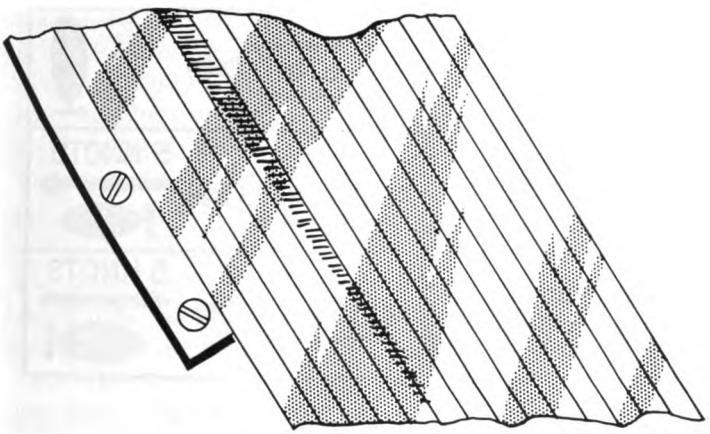

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About three-quarters of an inch of traces is usually required to get an accurate range rate. Report the range rate immediately after you report the range, Say "Range, one two hundred, range rate 10." Report the range rate about every 200 yards, and tell all stations whether the rate is opening or closing. If you note a change in the rate, report it and then get an accurate reading on the new slope. Always report "opening" or "closing" with the range rate in cases where this information isn't obvious.

If your ship is not headed toward the target, the range rate will be very low because your ship is not closing the range to the submarine. Therefore, read the first range rate when your ship has begun to head for the target.

When you are headed directly toward the submarine, the range rate will tell you whether the sub is coming toward you or going away from you. (Since your ship is not always headed directly toward the sub, don't depend upon range rate entirely. Doppler is a better means.) If

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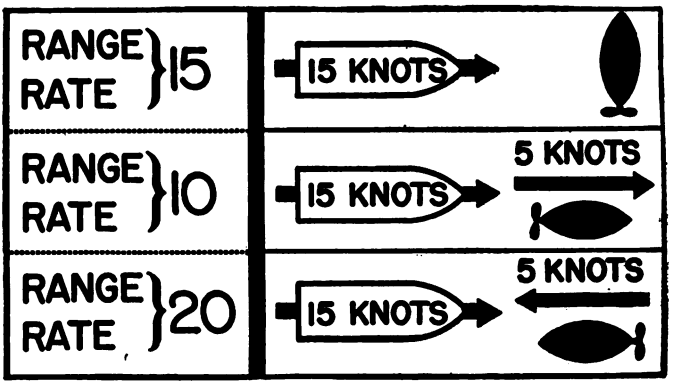

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the target is stopped or beam-on to you, you will close the range at a speed equal to your own ship's speed. That is, if you are making 15 knots, the range rate will be 15.

Suppose you were making 15 knots and heading directly at a sub that was going away from you at 5 knots. You would close the range at 15 knots minus 5 knots, and have a range rate of 10. If the sub turned around and came toward you, the range rate would change to 20 knots—your speed of 15 knots plus the sub's speed of 5 knots. These two cases are shown in figure 8–13.

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You know that you can obtain the correct firing time from the recorder. Firing time is the time at which depth charges should be dropped or throwing projectiles launched. However, before you call out the time to fire, you must make several adjustments to the recorder. Look back at figure 8–11. You can see the devices which make possible the accurate determination of firing time.

These devices consist of the plotter bar, plotter bar extension, range rate scale, firing lag scale, transducer-to-stern scale, and firing index. These are mounted on a casting which may be shifted in either the horizontal or

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vertical direction by means of the HORIZONTAL SLIDE KNOB and VERTICAL SLIDE CRANK, respectively. When you shift either up or down (vertical), you are correcting for time. When you shift either to the right or to the left (horizontal), you are making corrections for range.

The stern, bow, effective range (R_E), and backing plate scales, which are mounted on the recorder case cover, are also used to determine the correct firing time.

The transparent PLOTTER BAR and EXTENSION are used to determine range rate and firing time. They may be rotated about the pivot point by means of the PLOTTER BAR KNOB. The lines on the extension are used in reading range rate. The line and row of dots beneath it on the plotter bar proper form the FIRING LINE.

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The ZERO-ZERO scale to be used in checking zero-zero alignment is located on the left edge of the effective range scale. On older recorders it's just below the stern scale.

WHY MAKE ADJUSTMENTS?

You may be wondering why all these adjustments must be made on the recorder. One of the reasons is that no two antisubmarine attacks are exactly the same. For instance, you want to drop depth charges so that they will explode at the same depth as the sub. So if you think the sub is shallow, you will make adjustments on the recorder for sinking time. The same thing goes for a medium or deep sub.

You can compare these adjustments to the adjustments you must make on a camera before taking a picture. If you are shooting the finish of a horse race, you must adjust your camera for the speed of the horses. And you must adjust the recorder for the speed at which you are attacking the submarine. Another reason for an adjustment is the simple fact that the depth charges are located at the stern of your ship and the transducer from which you are getting ranges is located near the bow of your ship. You must make allowance for the distance between these two positions—so you have the transducer-to-stern scale, which takes care of this distance.

There's a reason for each adjustment. Your main responsibility is to make the adjustments before and during each attack. Read carefully and practice making the various settings on a recorder. In no time you'll become proficient in the operation of the recorder.

ZERO-ZEROING THE RECORDER

To get the correct time, the pivot point on the plotter bar must first be exactly on zero-zero because the pivot point is involved in all the adjustments you make on the recorder. The pivot point, you will remember, is the point about which the plotter bar turns, just as your shoulder

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socket is the point about which your arm turns. The initial position of this pivot point is the spot where the zero of the range scale meets the left edge of the transmission trace as the signal is going out. It's the zero range and zero time spot, which puts it in the upper left corner of the recorder time-range plot.

This pivot point must be exactly on the zero spot or the firing time will not be accurate—just as your weight would be indicated inaccurately if you weighed yourself on scales that did not line up at zero.

Putting the pivot point at the zero point of both time and range is called ZERO-ZEROING the recorder. Here are the steps. Follow them in the order in which they are given.

1. When zero-zeroing with scanning sonar, remove the TVG. tube from the sonar receiver set.
2. Turn the main switch to ON. Put the gear change lever in NEUTRAL.
3. Set the firing index to the No. 3 position and lock it there with the safety lever.
4. Move the pointer bar to zero on the transducer-to-stern scale, and to zero on the firing lag scale as shown in figure 8–14.
5. Put the flyback at about 1500 yards on the long scale.

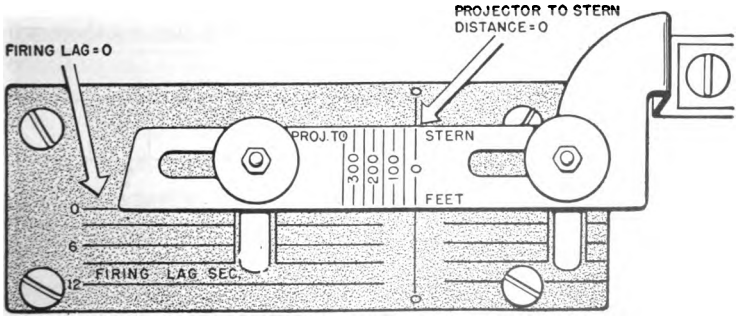

Figure 8–14.—Set these correctly.

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The main switch has four positions, OFF, HEAT, ON, and TEST. When the recorder is not in use, it is turned to OFF. If the temperature is below 35° F. the moist tape of the recorder may freeze, and you must turn the main switch to HEAT, as required by cold weather procedure. When the main switch is at HEAT, a current is passed through heating elements which warm the interior of the recorder. When in the ON position, the recorder controls the keying of the outgoing signal, just as did the keying relays in the console. The ON position is the normal operating position.

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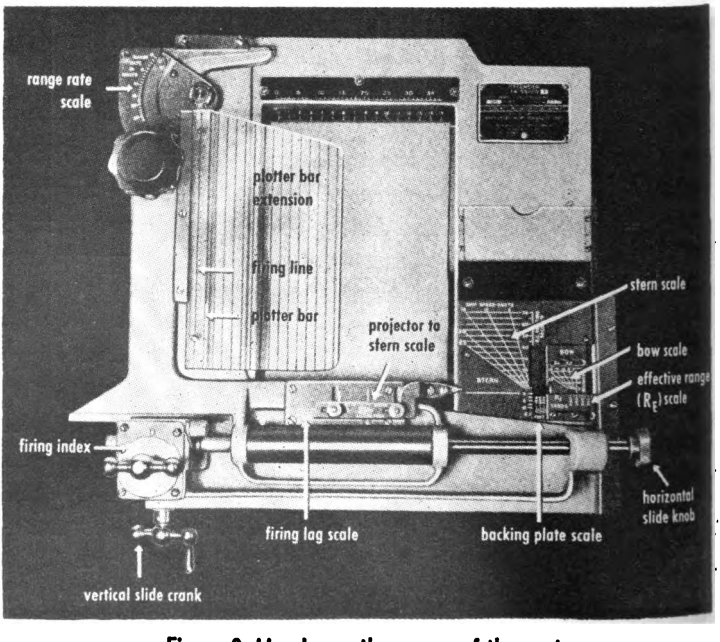

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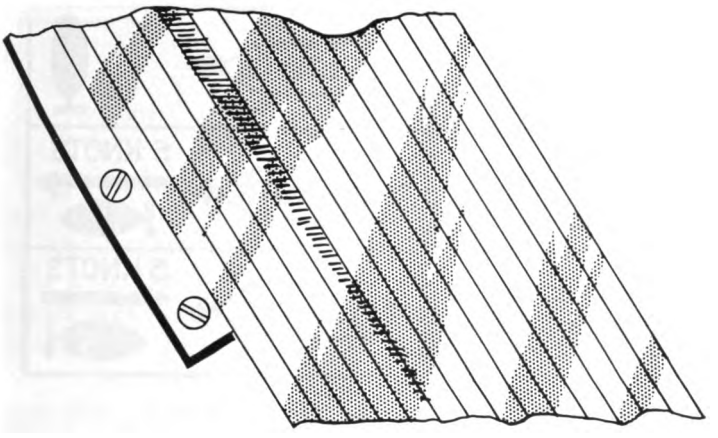

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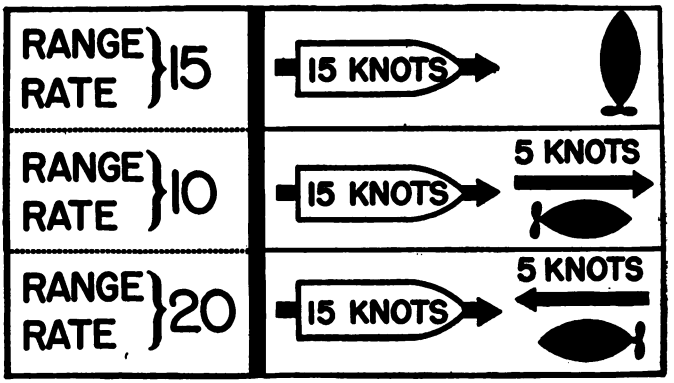

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The ZERO-ZERO scale to be used in checking zero-zero alignment is located on the left edge of the effective range scale. On older recorders it's just below the stern scale.

WHY MAKE ADJUSTMENTS?

You may be wondering why all these adjustments must be made on the recorder. One of the reasons is that no two antisubmarine attacks are exactly the same. For instance, you want to drop depth charges so that they will explode at the same depth as the sub. So if you think the sub is shallow, you will make adjustments on the recorder for sinking time. The same thing goes for a medium or deep sub.

You can compare these adjustments to the adjustments you must make on a camera before taking a picture. If you are shooting the finish of a horse race, you must adjust your camera for the speed of the horses. And you must adjust the recorder for the speed at which you are attacking the submarine. Another reason for an adjustment is the simple fact that the depth charges are located at the stern of your ship and the transducer from which you are getting ranges is located near the bow of your ship. You must make allowance for the distance between these two positions—so you have the transducer-to-stern scale, which takes care of this distance.

There's a reason for each adjustment. Your main responsibility is to make the adjustments before and during each attack. Read carefully and practice making the various settings on a recorder. In no time you'll become proficient in the operation of the recorder.

ZERO-ZEROING THE RECORDER

To get the correct time, the pivot point on the plotter bar must first be exactly on zero-zero because the pivot point is involved in all the adjustments you make on the recorder. The pivot point, you will remember, is the point about which the plotter bar turns, just as your shoulder

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socket is the point about which your arm turns. The initial position of this pivot point is the spot where the zero of the range scale meets the left edge of the transmission trace as the signal is going out. It's the zero range and zero time spot, which puts it in the upper left corner of the recorder time-range plot.

This pivot point must be exactly on the zero spot or the firing time will not be accurate—just as your weight would be indicated inaccurately if you weighed yourself on scales that did not line up at zero.

Putting the pivot point at the zero point of both time and range is called ZERO-ZEROING the recorder. Here are the steps. Follow them in the order in which they are given.

1. When zero-zeroing with scanning sonar, remove the TVG. tube from the sonar receiver set.
2. Turn the main switch to ON. Put the gear change lever in NEUTRAL.
3. Set the firing index to the No. 3 position and lock it there with the safety lever.
4. Move the pointer bar to zero on the transducer-to-stern scale, and to zero on the firing lag scale as shown in figure 8–14.
5. Put the flyback at about 1500 yards on the long scale.

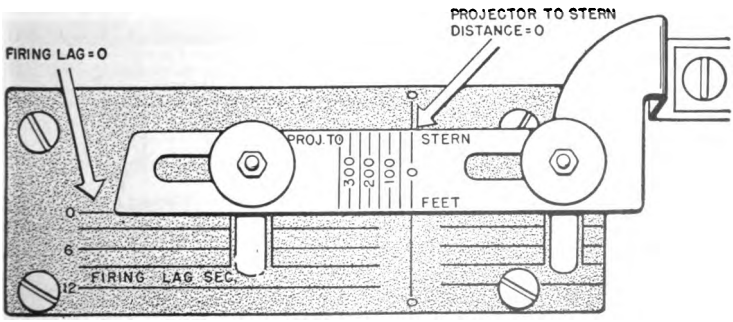

Figure 8–14.—Set these correctly.

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6. Shift the gear change lever to long scale.
7. Now wait for a transmission to go out, AND AS SOON AS THE STYLUS HAS MOVED A SHORT DISTANCE (NOT MORE THAN ONE-HALF INCH!), shift the gear change lever to neutral. You now have a trace of an outgoing signal at the upper left corner of the time-range plot. Several attempts may be necessary before this is accomplished satisfactorily. (You can also obtain a horizontal line by holding down the hand key and manually pulling the stylus across.) Turn the plotter bar into a horizontal position so that the zero marker is set at infinity (∞) on the range rate scale.
8. Shift the plotter bar up by means of the vertical slide crank until the firing line and row of dots beneath exactly line up with the last outgoing signal trace on the recorder tape. This position is shown in figure 8–15.

To avoid error in making this alignment, close one eye. Then with the other directly over the black firing line on the plotter bar, crank the bar up or down until the firing line, the row of dots beneath, and the outgoing signal are all lined up along one line.

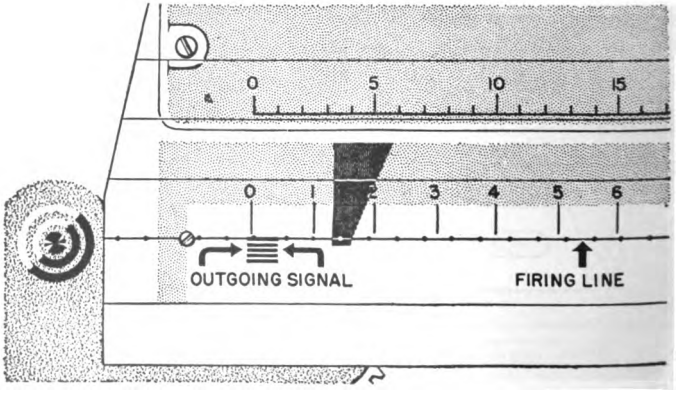

Figure 8–15.—Zero time.

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The pivot point of the plotter bar is now set at zero on the time scale.

To complete the zero-zeroing operation, you'll have to set the pivot point of the plotter bar at ZERO RANGE. This is the way to do it:

1. Shift the gear change lever to short-scale keying.
2. Set the flyback as far as it will go to the left. (On some installations, this may change the position of the outgoing signal. If this happens, move the flyback to the right until the outgoing signal again lines up correctly.)
3. Let the recorder run until a row of outgoing signals several inches long has been obtained.
4. Rotate the plotter bar downward to the vertical position, set the zero marker at zero on the range rate scale.

Close one eye, and with the other directly above the firing line, turn the HORIZONTAL SLIDE KNOB until the black line, the row of dots beneath, and the left edge of the row of outgoing signals are all exactly on a line with one another. Do not delay in making this adjustment because the recorder tape shrinks as it dries. This position is shown in figure 8–16.

The pivot of the plotter bar is now at zero range as well as zero time.

In figure 8–5 you were shown two types of outgoing signals: a heavy black dash and a blank space preceded by a dot. Regardless of the type produced by your recorder, use the left edge of the outgoing signal indication to line up the plotter bar.

An extra row of dots may appear at the extreme left of the tape because of action of the contacts. Do not confuse these with the dots representing the beginning of the outgoing signal.

If the outgoing signal does not start at zero range, the transmitting contact assembly has slipped, or was not adjusted properly when the lower guide bars were re-

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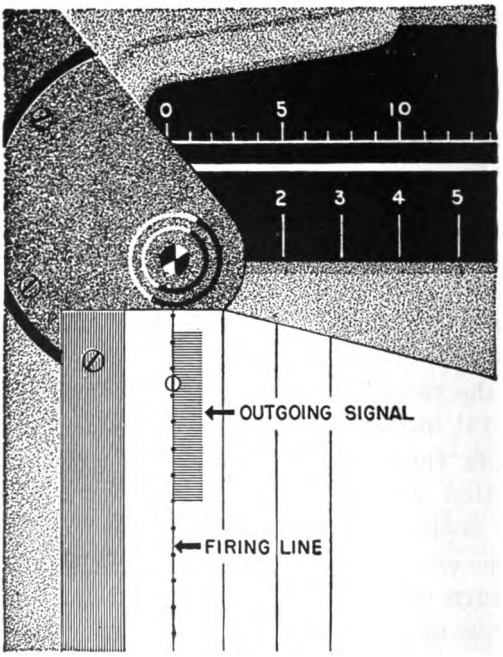

Figure 8–16.—Setting for zero range.

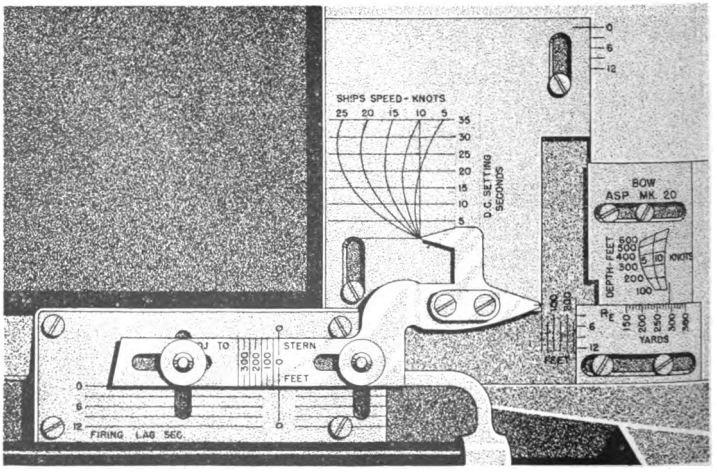

Figure 8–17.—Correct zero-zero position.

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placed. To correct this, loosen the flathead contact clamp screw and slide the transmitting contact assembly to zero range. (This may require more than one attempt.) Tighten the contact clamp screw, but do not overtighten, for you may easily strip the screw threads. Repeat the procedure above.

The data scale pointer should lie at the zero-zero point on the zero-zero scale, as it does in figure 8–17.

If the pointer does not point to zero-zero, loosen the two small screws holding the tip to the transducer-to-stern scale, and adjust the tip until it points to zero-zero.

NOTE.—If your recorder has a FIRING LAG DIFFERENCE SCALE, make sure that it is set to zero-zero. If the firing lag difference scale is moved, the ZERO-ZERO SCALE is also moved.

WHAT YOU SHOULD KNOW ABOUT FIRING TIME

Now that the pivot point is at zero-zero, you are ready to make the firing time settings on the various scales. Any correction that you make on any of the scales affects the pivot point. That is, by making the changes, you are either moving the pivot point up or down, right or left. The pivot point and the data scale pointer are mounted together so if you move one you move the other. Also the scales of time and range are the same as the speed of the tape (time) and the range scale on short scale.

There are two musts. You must be on short scale to fire properly because all firing adjustments are designed for short-scale range. AND YOU MUST HAVE THE FIRING INDEX IN THE NO. 3 POSITION WHEN ANY CORRECTIONS ARE MADE TO THE RECORDER.

Actually, firing time is obtained by lining up the firing bar with the slope of the traces, and waiting until the traces roll down under the firing line. When they pass under the line, it is time to fire. This position is shown with the pivot point of the firing bar at zero-zero in figure 8–18A.

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Now suppose you crank the pivot point straight up as in figure 8–18B. With the firing bar in this position, you would have to fire earlier than you did when the pivot point was at zero-zero. You shorten the time to fire by

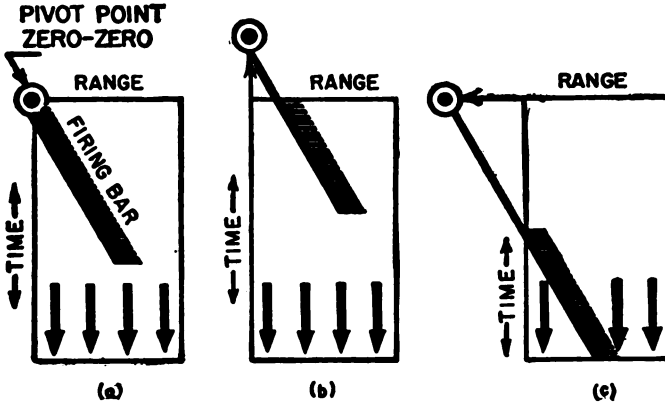

Figure 8–18.—Effect of moving the pivot point.

cranking the pivot point up and lengthen the time by cranking the pivot point down.

Look at figure 8–18C. The pivot point has been moved to the left, so you would have to fire later. You would wait a longer time for the traces to come down to the firing line. If you move the pivot point to the right, you would have to fire earlier.

There are several corrections you must make to get the proper firing time. The corrections for firing lag and transducer-to-stern distance can be made before an attack and do not have to be changed during the attack. Corrections for sinking time of weapons and for attack speed of your ship may have to be changed during an attack.

ADJUSTMENTS FOR DEPTH CHARGE ATTACKS

The first adjustment you must make for a depth charge attack is for FIRING LAG. Firing lag is the number of seconds that it takes from the moment you call "Fire!" until

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the depth charge actually hits the water. It takes a little time for the man on the firing lever to pull the lever, and it takes a short while for the charge to roll from the rack and hit the water. To allow for this, you must call "Fire!" a few seconds before you actually want the charge in the water. The greater the firing lag, the earlier you will have to call "Fire!"

When you fire from the recorder, you take care of this lost time by cranking the pivot point UP. This will allow you to fire earlier as illustrated in figure 8–18B. Suppose the lag is 3 seconds. First move the pointer bar down so that the bottom of it rests on the 3-second line of the firing lag scale.

In figure 8–19A, you can see that the plotter bar pointer is lowered 3 seconds. To set it to zero again, you must

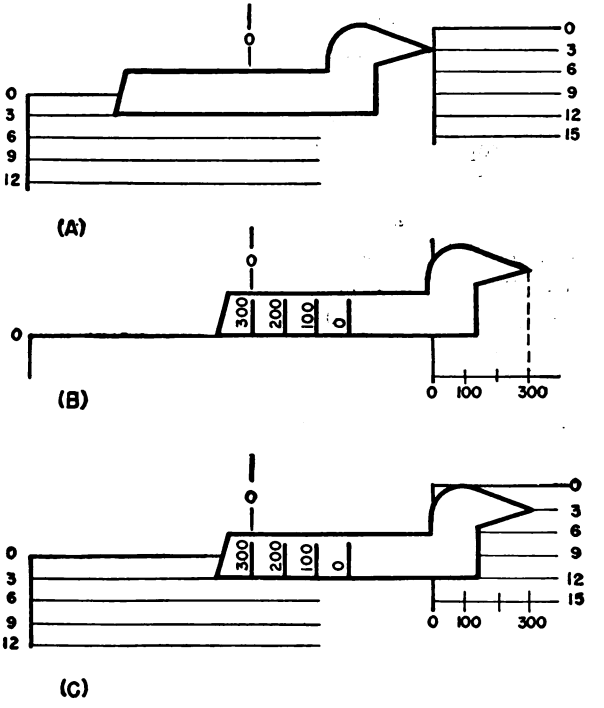

Figure 8–19.—Firing lag and transducer-to-stern distance.

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crank it up. This moves both the pointer and the pivot point up the required 3 seconds.

It's as though you'd moved the zero level down 3 seconds and then climbed back again to get the 3 seconds you need.

Standing instructions will indicate the number of seconds of firing lag for which you must correct on the recorder. It will probably be 3 or 4 seconds, depending on the equipment aboard your ship.

TRANSDUCER-TO-STERN DISTANCE

Another correction you'll make on the recorder is the transducer-to-stern distance. Look at figure 8–20. The transducer is directly over the submarine and range is zero. If you could shoot straight down from the transducer, you would hit the sub. But the depth charges are on the stern of the ship, perhaps 100 yards away. So you must wait until your transducer is 100 yards past the sub before you drop the charges. You correct for this distance on the transducer-to-stern scale.

Slide the pointer across to the right until the 300-foot line is opposite the zero mark. Look at figure 8–19B. This moves the pointer 300 feet to the right. Now when you crank the pointer back to zero, you will move the pivot point of the pointer back to zero, you will move the pivot point to the left and thus fire late—which is just what you want. Again it is as though you had pushed the zero point to the right, and then moved back the number of yards you desired.

These two corrections—firing lag and transducer-to-stern distance—are made on the same device and at the same time. Look at figure 8–20. Once they are made, you won't have to change them if you continue to make depth charge attacks. Incidentally, the transducer was once called a "projector," and most tactical range recorders still carry the abbreviation "proj."

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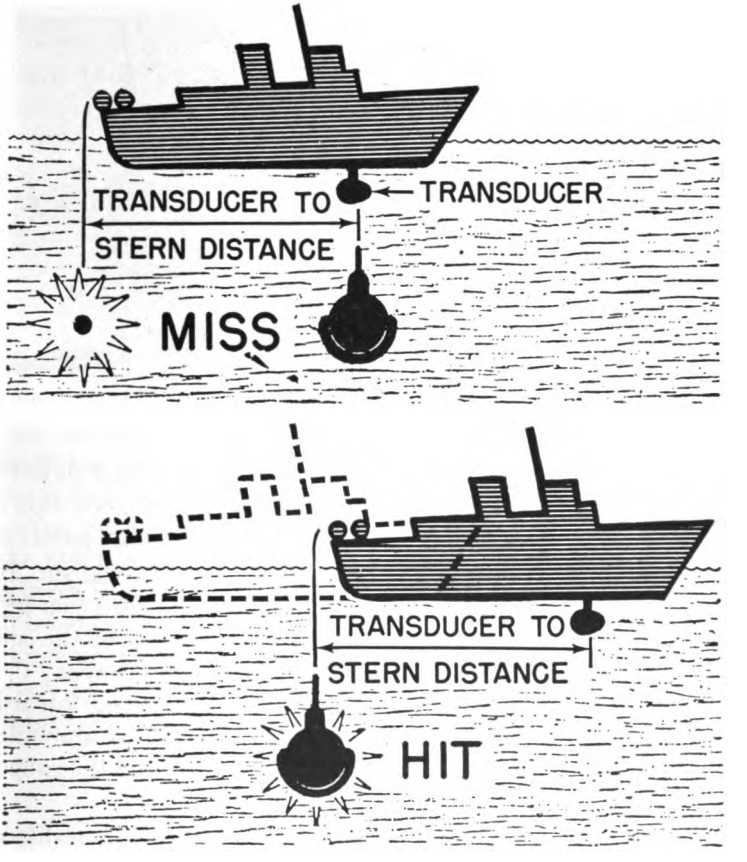

Figure 8–20.—Transducer-to-stern distance.

SINKING TIME AND ATTACK SPEED

There are only two other corrections for a depth charge attack. One is for sinking time of the charges and the other for own ship's attack speed. For fast-sinking charges, a double pointer (see fig. 8–21) is required. The left pointer is for settings on the stern scale (depth charge attack), and the right for settings on the bow scale (throwing attack).

The slanting lines represent ship's speed, and the hori-

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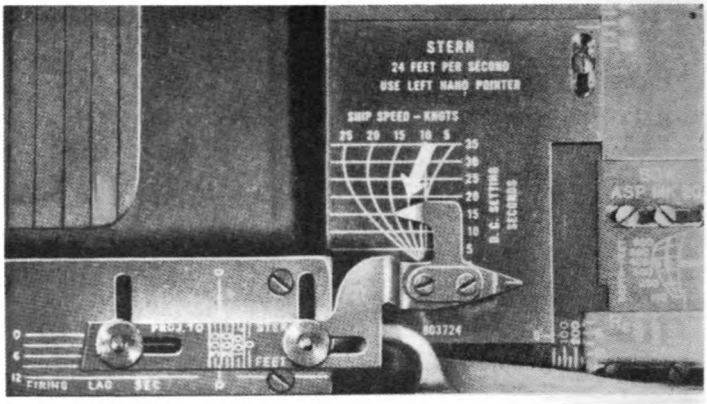

Figure 8–21.—Attack speed 15 knots, sinking time 15 seconds.

zontal lines are depth charge sinking times. All you have to do is crank the pointer to the spot where own ship's speed meets the sinking time of the depth charge pattern.

Remember, you drop the charges in front of the sub. If it is heading toward the ship, drop them before you get to the sub. If it is going away, you have to go over the sub and drop the charges on the other side. This is what the recorder does. It tells whether the sub is coming toward or going away from the ship, and it does this by showing you the difference between own ship's speed and the range rate.

You remember that a range rate greater than own ship's speed means the submarine is coming toward the ship. If the ship is headed directly toward the sub and the range rate is less than own speed, the sub is going away from the ship. So when you set the pointer on own ship's speed line on the stern scale, the recorder automatically compares the attack speed and the firing range rate.

Once an enemy submarine is caught in the sonar beam, its only hope is for you to miss it with your depth charges. That's where the stern scale of the recorder comes in. You can crank the pointer up to the desired sinking time of the charges and over to the attack speed, and the recorder

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will indicate the time the depth charges should be dropped on the sub.

For instance, suppose you are attacking a submarine that is 600 feet deep. It will take 26 seconds for the charges to sink to the sub's depth, that is, 600 feet. If the sub is going 6 knots, you will have to drop the charges 100 yards in front of the sub because the sub travels 200 yards a minute at 6 knots.

But if the sub were only 100 feet deep, the charges would take only 4 seconds to sink to that depth, and you would drop the charges 9 yards in front of the sub. So let the recorder "know" how many seconds of sinking time you require by cranking the pointer up to the desired sinking time line. You complete the setting-up process for dropping depth charges by cranking the pointer over to the attack speed.

You've probably noticed that own ship's speed lines on the stern scale of the recorder are curved lines. There's a good reason for this. The range is measured from the transducer to the sub and this, of course, is not the same range as from the transducer to a point on the surface over the sub. Look at figure 8–22. The range on the recorder—from the transducer to the sub—called the

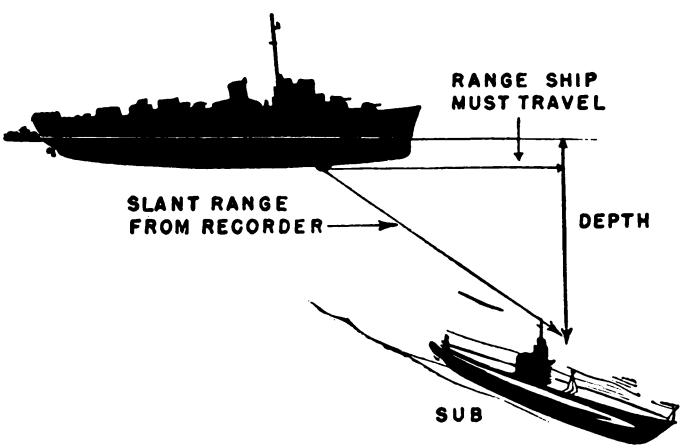

Figure 8–22.—The slant range is shown on the recorder.

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SLANT range, is larger than the surface range over which the ship moves. This difference has been taken into account on the recorder. The correct curve has been calculated, and therefore no error exists.

THE FIRING INDEX

The depth charge pattern you will drop is composed of many charges. They are dropped at set intervals and cover a large area. All the reckonings are made for the center charge of the pattern and, quite naturally, some charges are dropped before and after this center charge. The firing index that you can see in figure 8–23 is the means of spacing the charges in the pattern.

All corrections are made with this index in the center position, No. 3. When you turn the handle and the index points to position 1, you push the pivot point and the firing bar to the right. Therefore, in No. 1 position you will fire early. After you fire 1, turn to No. 2 position. This moves the firing bar to the left. Wait for the traces on the

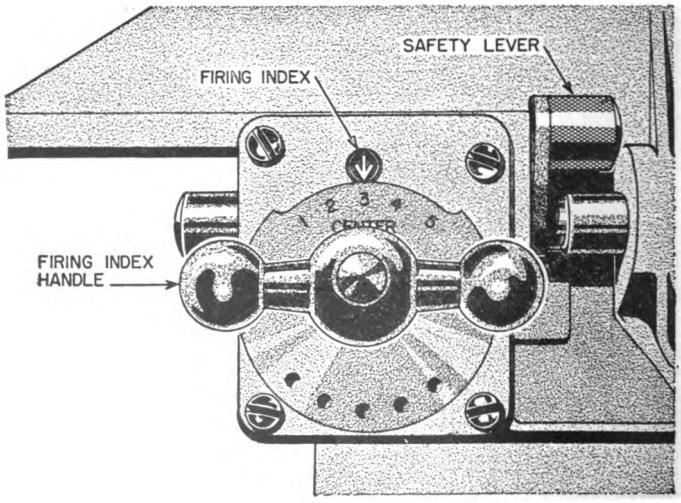

Figure 8–23.—This automatically spaces the charges.

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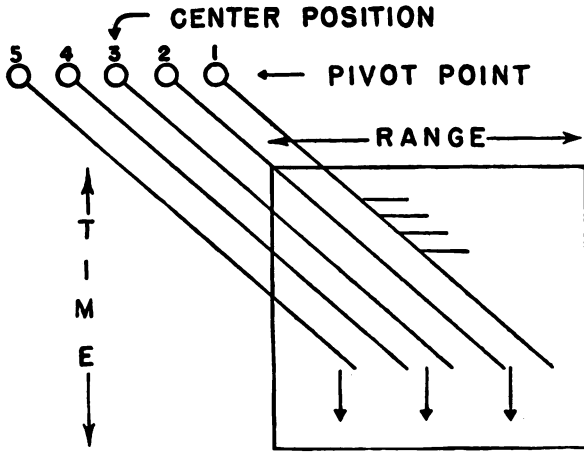

Figure 8–24.—There are 40 yards relative to the submarine between each position.

moving recorder tape to come down to the firing bar again, and when they arrive, say "Fire two!"

Look at figure 8–24 for a pictorial description of this. You turn next to the center position, No. 3, and wait again for the traces to come down to the bar. Watch intently, and announce "Fire center!" Then turn to the Nos. 4 and 5 positions, repeating this routine. You can see now how the firing index gives you the proper time for all five steps of the normal depth charge pattern.

CHOOSING THE RANGE RATE

There is an important point in depth charge attacks that must not be overlooked. And that is—On which range rate should you fire? In figure 8–25, the DE starting at A makes a good run, dropping charges at D, about 100 yards ahead of a fast sub.

If the sub is shallow, the DE might hold contact for the entire run, and the recorder operator would have traces similar to the ones shown in the illustration. But notice what happens to the range rate. From points A to B it is

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about 15 knots, but from 500 to 300 yards it has dropped to 13. At points close to D, the range rate is almost zero because you have stopped closing the range and are passing in front of the sub.

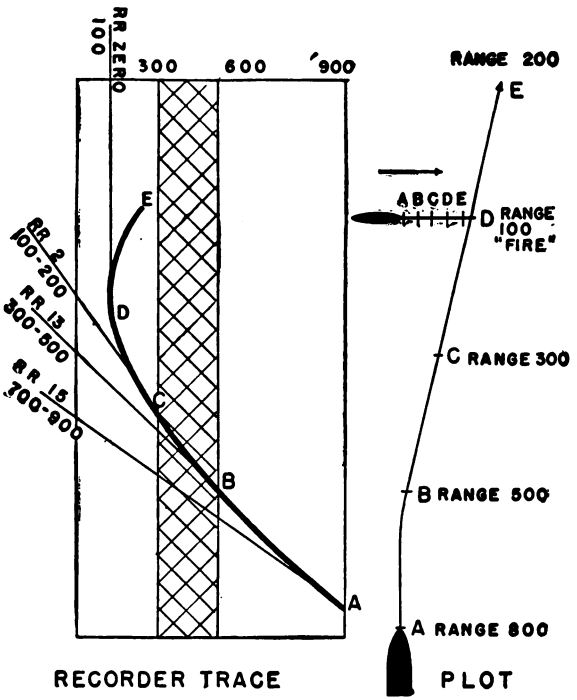

Figure 8–25.—Which range rate should be used?

Which of these range rates should you use for firing? At the earliest one, 15, you are too far away from the sub. But the range rate at D is about zero and you cannot fire on a range rate of zero—the traces would never hit the firing bar.

For best range rate indication, use the last three-fourths inch of traces before the ship takes the attack course. These traces are neither too close nor too far away. Line up the traces and, about 15 seconds before

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they come under the firing bar, say "Stand by depth charges." Announce the firing range rate to all stations. Then concentrate on the traces and the firing bar. Put your head over the plotter bar so that your eyes are looking straight down through the dots. When the traces come under the firing bar, call loudly and clearly "Fire one!" MAKE SURE THAT YOU SWING THE FIRING INDEX TO THE No. 1 POSITION BEFORE FIRING No. 1. If you forget and leave it in the No. 3 position, the whole pattern will be fired late. After firing No. 1, swing to the next position, and carry on until you have fired the entire pattern.

You must report the range whenever contact is lost. The stack operator will say "Lost contact, last bearing ——." You immediately follow with "Last range, three hundred" (or whatever it was).

One more point to remember: Leave the flyback where it is until 1 minute after the charges explode, then shift to long-scale keying.

FIRING EARLY AND LATE

At the last stage of an attack, the conning officer may order you to fire early or late. This correction will be necessitated by last-minute maneuvers of the sub or your own ship. The recorder does not automatically take care of these things. So as soon as you receive the order, crank the pointer either straight up or straight down, depending on whether you must fire early or late. To fire 5 seconds early, turn the vertical slide crank until the pointer has moved up 5 seconds as measured by the lines of the stern scale. One and a half turns moves the pointer 5 seconds.

To fire 10 seconds late, turn the vertical slide crank until the pointer has moved down 10 seconds (2 lines) on the stern scale. DON'T TOUCH THE HORIZONTAL SLIDE KNOB. The vertical slide crank controls up and down, early and late, and time corrections.

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The recorder also indicates time for launching throwing weapons. The various scales used in this type of attack are shown in figure 8–26.

The bow scale is merely a small edition of the stern scale. The data scale pointer must be shifted so that it falls on the proper intersection of attack speed and sinking time on the bow scale—just as it did on the stern scale during a depth charge attack.

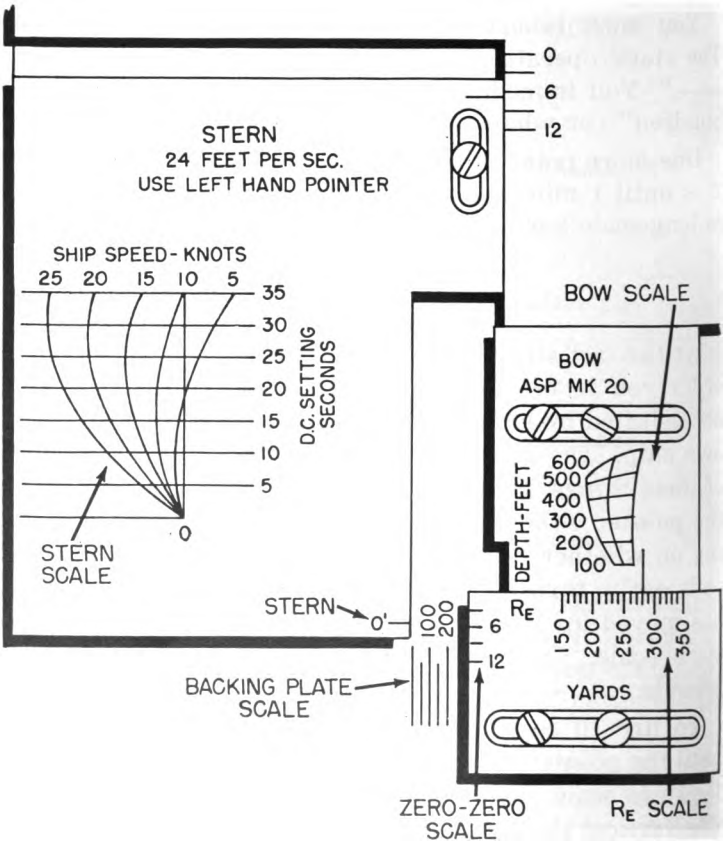

Figure 8–26.—Scales for throwing attacks.

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The R_E (EFFECTIVE RANGE) SCALE is located beneath the bow scale and is used in throwing attacks to correct for many factors. Since the transducer-to-stern distance set for depth charge attacks is not necessary for throwing attacks, the R_E scale is moved a distance equal to that set on the transducer-to-stern scale. This distance may be read on the backing plate scale. This is 290 feet in figure 8–26 and it cancels out transducer-to-stern distance for throwing attacks.

After the R_E scale has been slid so that its left edge is at the proper spot on the backing plate scale, the bow scale is moved until the vertical line on the right side of the bow scale is directly over the desired effective range on the R_E scale. This effective range is 300 yards in figure 8–26.

THE R_E

The effective range is the total of many factors. Some of these are the range of the projectiles, the distance from transducer to thrower, distance from thrower to water line, forward underwater carry of projectiles, range correction for powder temperature and projectile weight, and so on.

The range for firing throwing patterns must be calculated accurately. Compute a new R_E setting each watch. It is very important that all these settings are made very carefully, and checked and doublechecked.

LAST-MINUTE BRIEFING

One big difference between the settings for depth charges and for throwing attacks is in the firing lag. In throwing attacks, there is a long time interval after the order to fire is given until the projectiles hit the water. For example, hedgehogs of current issue fly through the air for about 8 seconds. For the Marks 10, 11, and 15 THE FIRING LAG IS ALWAYS 10 SECONDS. There are 8 seconds of flight time plus 2 seconds of dead time. You will

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set this on the firing lag scale just as you set the depth charge firing lag.

When you fire throwing weapons, you must check every detail carefully. With care, you can fire at the correct range, but a small error will result in a clean miss. Use the last range rate available.

After you call "Stand by!" turn all your attention to the traces. Use the last three-quarters of an inch of traces and change the plotter bar constantly so that you may keep it lined up exactly with the traces. Continue to do this until you call "Fire!"

OPERATING THE RECORDER DURING AN ATTACK

After the recorder has been cut in, you must go through the following procedure. It has all been discussed in this chapter, but a summary will fix each step firmly in your mind.

1. Maintain the proper keying interval of outgoing signals by keeping the flyback in the correct position.
2. Shift from long to short scale when the range of the target is about 200 yards less than the maximum range on short scale.
3. If echoes are very weak, delay the shift.
4. Report ranges after every bearing.
5. Range reports must be coordinated with bearing reports made by the sonar operator. Usually the recorder operator will call out the range immediately after the sonar operator has reported a bearing. In depth charge attacks, make a special point of calling out the range at 1200 yards and 700 yards.
6. Interpret the trace, and report target aspect and changes in target aspect.
7. INFORM ALL STATIONS OF ANY CHANGE IN TARGET ASPECT—EVEN BEFORE YOU KNOW DEFINITELY THE DIRECTION OF CHANGE.

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8. Report range rate as soon as it may be determined after the attack ship is headed at the target. Thereafter, report range rates at approximately every 200 yards change in range.
9. INFORM ALL STATIONS QUICKLY OF ANY CHANGE IN RANGE RATE AND THE DIRECTION OF CHANGE. DO NOT WAIT FOR AN EXACT VALUE OF THE NEW RATE.
10. Make any necessary changes in settings of the firing time devices.
11. After changing firing time settings, or after shifting to short scale (if no changes were made), shift the firing index to No. 1 position. This won't affect the recorder settings, and you avoid the possibility of not shifting at all.
12. Adjust the plotter bar to the correct range rate.
13. Give the STANDBY warning 15 seconds before firing time.
14. To concentrate on lining up the plotter bar for firing time, stop reporting ranges after calling STANDBY.
15. Call out FIRE when the correct portion of the traces passes beneath the firing line.
16. When the pattern is dropped, wait approximately 1 minute, then shift to long scale.

ONCE EVERY WATCH

Every watch, check the recorder tape supply so that you will not run out during an attack. Check the recorder by cutting it in at least 5 minutes during each watch. Pay particular attention to the flyback and keying mechanisms. MAKE SURE THE RECORDER IS ACCURATELY ZERO-ZEROED. Check the preattack settings of the firing time devices.

The recorder is designed for use in developing a contact and making attacks and reattacks. Day-to-day searching should be done from the stack.

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QUIZ

1. What is range rate?
2. The record of traces on the recorder chart is spoken of as a type of plot. Name this plot.
3. What are the three positions of the gear change lever?
4. What control governs the printing of the trace?
5. As the range closes, when do you shift from long scale to short?
6. If your ship was closing the range using a 15-knot attack speed and the sub was headed toward you at 3 knots, what would the range rate be?
7. Where, on the recorder, is the correction made for the time elapsing between "will to fire" and the moment when the charges strike the water?
8. Where is the pivot point on the plotter bar located when you zero-zero the recorder?
9. Why must the recorder be on short scale before firing?
10. Where should the flyback be kept on long-scale keying?
11. What is R_E?

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CHAPTER 9

SONAR COMPUTER GROUP

Azimuth search sonar provides range and bearings of the underwater target, and depth sonar tells you how deep the target is. Operating independently, neither sonar set can give you the exact location of the target. Another equipment, called the sonar computer-recorder group, combines information from search sonar, depth sonar, and bathythermograph to fix the submarine's position in range, bearing, and depth. This information is fed into the underwater fire control system where antisubmarine weapons are brought to bear on the target.

There are two models of computer-recorder equipments: OKA–1 and AN/SQA–4. Essentially, they are the same. Model AN/SQA–4 is a modification of the OKA–1 redesignated according to the AN nomenclature system. Although the OKA–1 is in all respects a computer-recorder group, it carries the older title, Sonar Resolving Equipment.

The main components of the computer-recorder group are a range recorder, a depth recorder, and a sonar data computer. (See fig. 9–1.) One of the differences between the SQA–4 and OKA–1 is that the depth recorder is a separate unit in the SQA–4 group, and it is a part of the depth-determining equipment in the OKA–1.

No simple statement can cover all the jobs a computer-recorder group performs. Its primary function is to cal-

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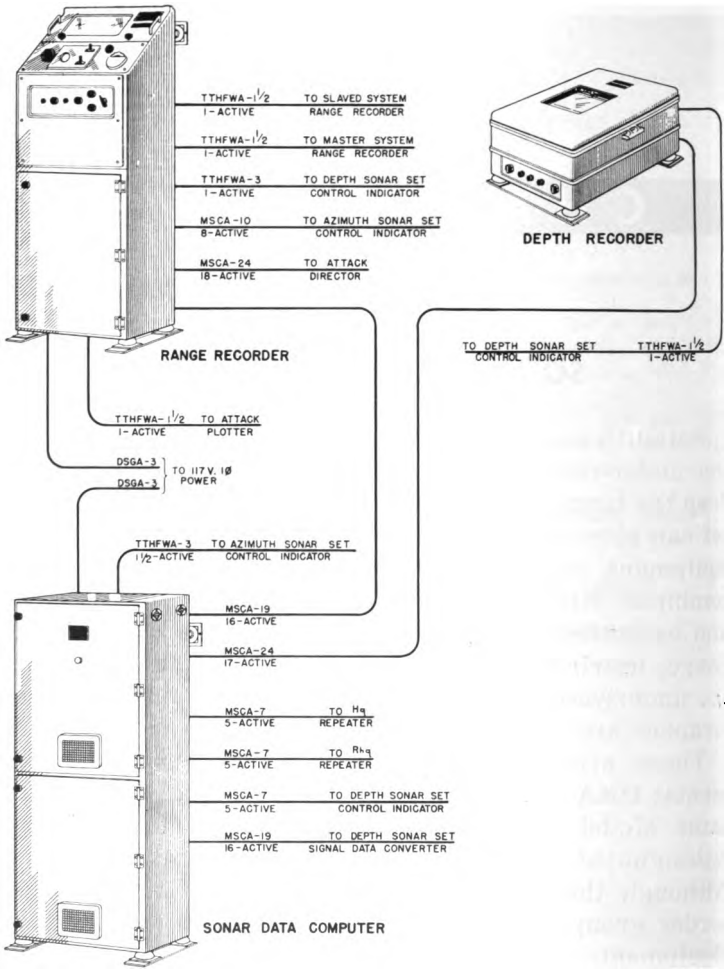

Figure 9–1.—Computer-recorder group.

culate and transmit the HORIZONTAL RANGE of a sonar target. This is the distance from your ship to a point directly over the target, measured across the surface of the ocean. Success of the antisubmarine attack depends upon accurate calculation of horizontal range. The com-

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puter-recorder group does not transmit or receive sound; therefore accuracy of its calculations depends upon the accuracy of the azimuth and depth sonars.

THEORY OF SOUND

To appreciate the work of computer-recorder equipment, you will need a short review of the theory of sound, as studied in chapter 4.

You learned that the velocity of sound in sea water is affected by salinity, pressure, and water temperature. Of the three, water temperature has the greatest effect on the speed of sound through water. Sound travels faster through warm water than through cold. In a mixed (isothermal) layer, temperatures are constant; therefore sound travels at a constant velocity and on a relatively straight course. To compute the range to a target in a mixed layer, you need only divide in half the time required for transmission and echo return, and multiply this figure by the velocity of sound as indicated by water temperature. This is essentially what is done by the tactical range recorder (see chapter 8).

Because sound travels slower in cold water than in warm, a variation of temperature in depth will bend the sound beam. Thus, if the water is cold at the surface with an underlying layer of warm water, the sound beam will bend upward. If temperature decreases with depth, the beam will bend down. How sharply it bends, or refracts, depends on how great a temperature difference exists.

As you already know, a layer of water in which temperature decreases RAPIDLY is called a thermocline. Although there are different types of layers, the thermocline is commonly referred to as THE LAYER. Anytime you hear an expression such as "The layer is at 80 feet," you know that this particular layer is the thermocline and it commences at a depth of 80 feet.

When a sound beam DEPRESSED AT A SMALL ANGLE enters the thermocline, marked refraction takes place. Because the sound is spreading as it leaves the transducer,

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the bottom of the beam angles slightly down. When it enters the thermocline, the bottom of the beam is slowed and sound is directed downward at an even greater angle with respect to the ocean surface. If a sonar target lies below the thermocline, at long range (when you must work with small depression angles) you will get echoes from the target only by directing the beam ABOVE the target. Refraction—not the angle of depression of the sound beam—brings in the echo. Unless allowance is made for refraction, target indication on your equipment will be false. You can see an example of this in figure 9–2. Without the aid of the computer, your sonar set would indicate target position at "A." Actually, "A" is located above and at greater range than true target position. The angle of depression in this case is not true, hence it is called the APPARENT depression angle and carries the symbol E*q*.

The sonar computer-recorder group overcomes some of the limitations of the older tactical range recorder you studied in chapter 8. The TRR cannot correct for refraction because it makes no allowance for changes in the velocity of sound. It provides sonar with slant range to the target. With suitable corrections and a mixed layer, this is close enough to horizontal range for accurate weapon fire. Where marked refraction exists, the TRR is not accurate enough.

Figure 9–2 contains a number of symbols that may

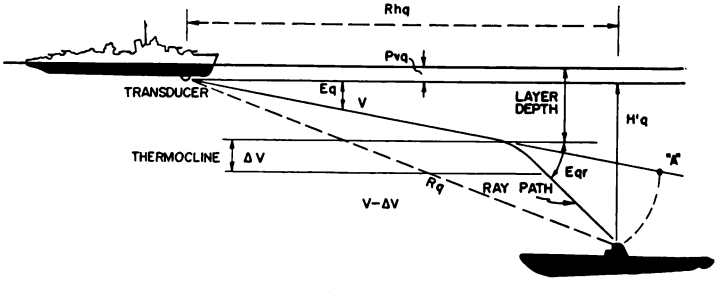

Figure 9–2.—Sound beam refraction.

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seem strange at first glance, but you are already acquainted with most of their values. Each symbol will be explained, and if you take the trouble to check the explanation against figure 9–2, you should have no trouble remembering its meaning.

SYMBOL	MEANING
Rq	Sonar range. This is the distance from the transducer to the target ALONG THE PATH OF THE SOUND BEAM. It is sometimes called SLANT range.
dRq	Range rate.
Rhq	Horizontal range. This is the distance from the transducer to the target measured over the surface of the ocean. Horizontal range, *Rhq*, is a projection of sonar range, *Rq*, on a horizontal plane.
Eq	Sonar depression. This is the angle the beam is depressed by the depth-determining sonar. It is the apparent angle of depression of the sound beam to the target with respect to the ocean surface.
Eqr	Refracted depression angle. This is a measurement of the bend of the sound beam. Notice in figure 9–2 that it commences when the beam enters the thermocline.
H'q	Relative target depth. Depth measured vertically from the center of the transducer to the center of the target. This is not true target depth because it does not allow for the distance from the surface to the center of the transducer. (See fig. 9–2.)
Pvq	Transducer depth. Depth of depth-determining transducer, measured vertically from the ocean surface to transducer center.
Hq	True target depth. This is measured vertically from ocean surface to target center ($H'q + Pvq$).
V	Velocity of sound in a mixed layer.
ΔV	Decrease of velocity of sound in thermocline.

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One of the symbols in figure 9–2 is V, the velocity of sound in a mixed layer. You also see it as $\triangle V$. This second symbol, $\triangle$, is the Greek letter delta, and is called a QUANTITY MODIFIER. When placed before another symbol (or quantity) it means a change in or increment of that quantity. Thus, $\triangle V$ indicates a change in the velocity of sound.

Another quantity modifier is the letter c. Placed before a quantity, it means that the quantity is not an observed value, but is generated by the equipment.

Suppose we combine these modifiers in an example. In aided tracking, the equipment generates the depression angle, $cEtq$, required to keep the sound beam on the target. Increments, or units, of the depression angle are labeled $\triangle cEtq$.

Most bathythermograph readings indicate a mixed layer varying from 50 to 150 feet, then a region of thermocline, followed by another layer in which temperature decreases slowly. Another fairly common condition is one in which temperature decreases almost continuously in depth from the surface down. In the second case, the beam is refracted downward as it passes from layers of higher sound velocity to layers of lower velocity. (A positive thermal gradient will deflect sound upward, but BT readings of this type are fairly rare.)

Layers above and below the thermocline in figure 9–2 are mixed, and once sound enters these layers it moves on a straight line. In the thermocline, the path of the sound beam curves because temperature is decreasing rapidly with depth, and sound velocity is decreasing with temperature.

Errors produced by refraction are compensated by circuits of the computer-recorder group. The equipment continuously computes the refracted depression angle, Eqr, based on BT readings and the apparent depression angle, Eq. Velocity of sound governs the speed of the depth recorder stylus. The depth recorder stylus motor receives a voltage at a frequency proportional to the velocity of

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sound, *V*, times the apparent depression angle, *Eq*. This value is called the vertical component of the velocity of sound, *Vz*. To make the stylus speed proportional to *Vz*, the equipment ceases to use *Eq* and substitutes angle *Eqr* as soon as the sound reaches the thermocline. Contacts in the path of the stylus shift the equipment from angle *Eq* to *Eqr*. These contacts actuate a relay in the sonar data computer which selects the angle *Eqr* for the remainder of the stylus excursion. The shift from *Eq* to *Eqr* changes the frequency of voltage to the stylus motor. When the stylus returns, angle *Eq* resumes control until the stylus again reaches the layer depth contacts.

Once slant range, *Rq*, and target depth below the depth-determining transducer, *H'q*, are available, the equipment then computes the target depression angle, *cEtq*. This is the angle at which the depth-determining sonar beam must be transmitted to hold contact, and it will change as the target closes. As a matter of fact, it will change rapidly in the final stages of the attack.

You remember from your study of bearings and motion that bearings move rapidly down the side of the azimuth sonarscope in the final stages of an attack. The same thing happens with the depression angle as you approach a submarine to pass over it. Keeping on target would be difficult but for AIDED TRACKING. The computed depression angle, *cEtq*, is transmitted by synchro to the depth-determining sonar to keep the sound beam on target even when *Eq* is changing rapidly.

HORIZONTAL RANGE

Horizontal range, *Rhq*, is calculated from the computed depression angle, *cEtq*, and slant range, *Rq*. The system provides a voltage that is proportional to slant range times the cosine of the computed depression angle. By definition, this voltage is horizontal range, *Rhq*, since—

$$Rhq = Rq \cos cEtq.$$

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Horizontal range is not displayed by the computer-recorder group. This value is transmitted to the attack director, or other fire control equipment.

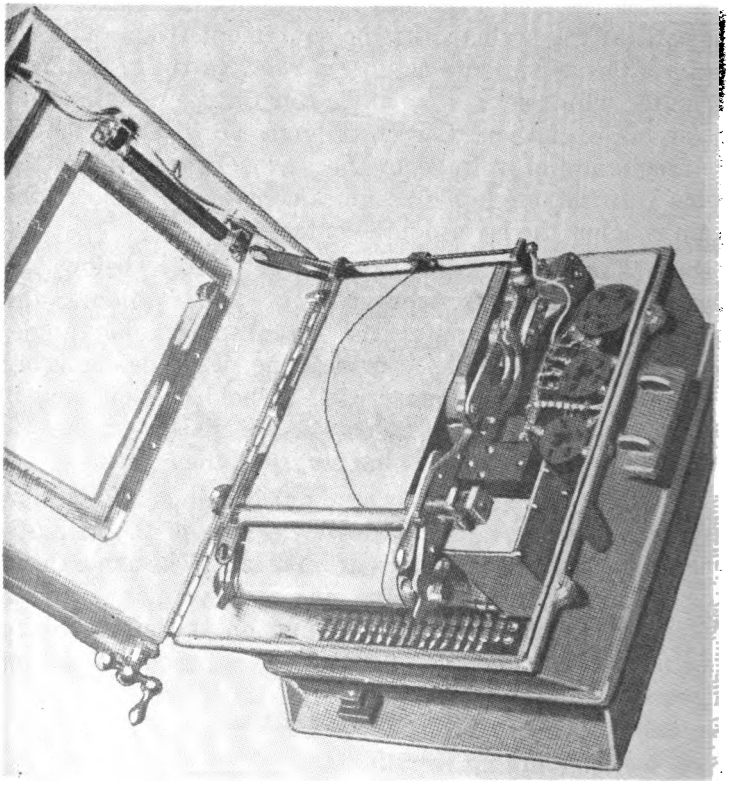

Figure 9–3.—Horizontal range recorder.

In some installations *Rhq* is displayed by a horizontal range recorder. This is a modified TRR with a nonreciprocating stylus. The stylus burns a steady line as a continuous indication of range, as shown in figure 9–3. When the range closes sufficiently, the recorder provides firing time. The slope of the line is an indication of range rate, *dRq*.

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RECORDING RANGE

The range recorder component of AN/SQA–4 and OKA–1 uses the same principles of operation to print echoes as does the TRR. A reciprocating stylus moves across moist, chemically sensitized paper; the paper moves downward at a constant rate. Current passes from the stylus, through the paper, to a platen which provides a ground. The time of arrival of an audio signal is burned on the paper.

Main difference in operation of the TRR and the SQA–4 and OKA–1 recorders is stylus speed. The stylus of the latter two recorders is driven at a speed proportional to the velocity of sound, according to water temperature settings calculated from the latest BT drop. (Exact settings for temperature variation are a matter of fleet doctrine and will not be discussed here.)

OPERATING THE RANGE RECORDER

The range recorder has two control panels, one at the front and the other on top. First, consider the controls located on the top panel. (Throughout this discussion, refer as necessary to figure 9–4.) To the left is a knob attached to a dial visible through a small window. This is the range rate control with which you position the optical plotter bar (cursor) of the recorder mechanism. In effect, you are performing the same function as when you move the plotter bar of a tactical range recorder—the more slope to the cursor line, the higher the range rate. You read the range rate from the dial to the right of the range rate knob.

Once you set the angle on the cursor you don't have to change it again unless the range rate changes. Because the optical system (which produces the cursor) is able to track the target, it is referred to as an AIDED FOLLOWER. Here is what happens: Moving the range rate control knob causes a motor to take charge of the cursor and the target is tracked automatically. The higher the range rate, the

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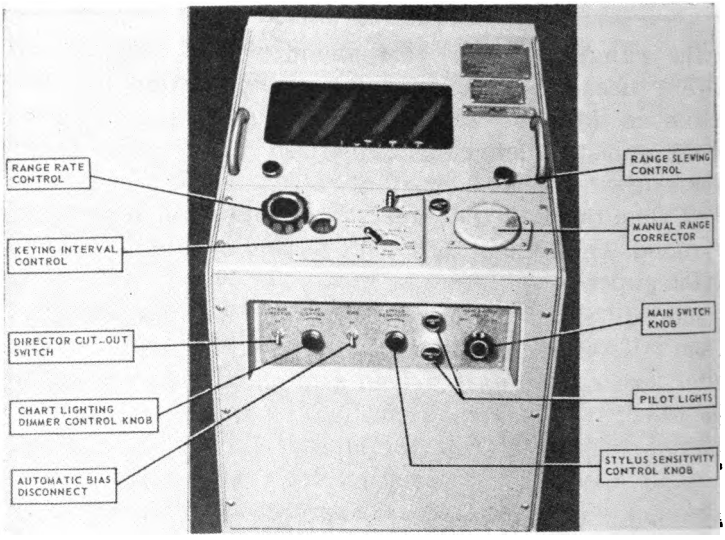

Figure 9–4.—Range recorder.

faster the cursor moves toward the left. In normal operation, the keying interval also shortens as the range decreases, just as it does when you bring in the flyback on a conventional tactical range recorder. The stylus returns after passing a short distance (about 200 yards) beyond the cursor line.

Keying Interval Switch

Look again at figure 9–4. This time notice the keying interval switch. It has three positions—center, left, and right—labeled RANGE VARIABLE, FULL SCALE, and LONG SCALE.

You just learned that the stylus returns after passing about 200 yards beyond the cursor line. This happens when the keying interval switch is set at RANGE VARIABLE, its normal operating position. If you move the keying selector switch left or right you will cause the stylus to move all the way across the chart in what is known as

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full-scale excursion. Here is the reason: Unlike the TRR, the SQA–4 and OKA–1 range recorders have two flybacks, one fixed at the extreme right of the chart, the other capable of traveling with the cursor. Moving the keying interval switch to the left or right causes the stylus to bypass the variable flyback and travel all the way to the fixed flyback.

In the left position, the stylus crosses the chart completely, and there is no change in stylus speed. In other words, if your equipment is keying on short scale (stylus moving at a fast rate), it will continue to move fast when the switch is moved to the left. If the equipment is on long scale (stylus moving slowly), it will continue to move slowly as it crosses the chart.

In the right position the stylus also travels completely across the chart, but ALWAYS AT SLOW SPEED because the equipment is operating on long scale. The switch can be locked in the left position when you want to get echoes from different targets, but there is no right position locking arrangement.

Near the keying interval control is another toggle switch. This slews the cursor left or right and is used when the operator wants to match the cursor with the incoming range.

Front Panel

Front panel controls need little explanation. The purpose of the chart light dimmer control, stylus sensitivity control, etc., should be clearly evident. A switch marked ATTACK DIRECTOR is moved to the ON position when information from the computer-recorder group is transmitted to an underwater fire control attack director. The BIAS switch provides a better signal-to-noise ratio. If reverberations are strong, turn on the bias switch to filter some of the background noise. It is possible to filter out weak echoes, so exercise care in the use of the bias switch.

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DEPTH RECORDING

The depth recorder of the SQA–4, shown in figure 9–5, is similar to the range recorder, except that the stylus has a very wide speed range. The depth recorder stylus travels at a speed proportional to the sine of the target depression angle. In other words, the stylus moves at a rate corresponding to the slope of the sound beam. If the beam is

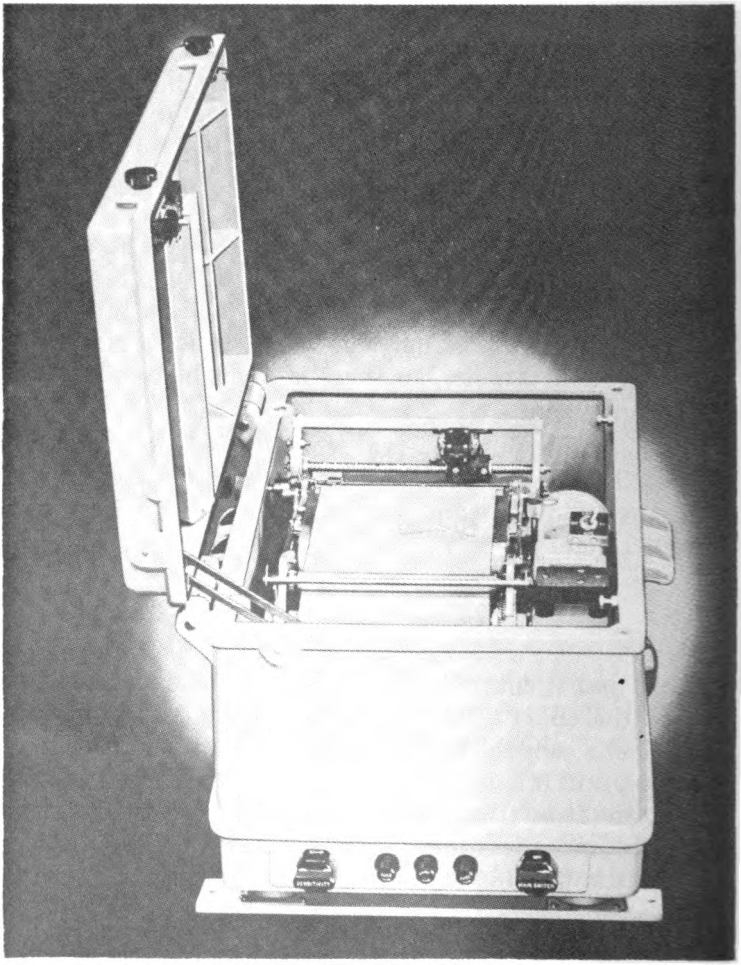

Figure 9–5.—Depth recorder with top cover raised.

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steep, the stylus moves rapidly from left to right; if the beam is nearly horizontal, the stylus moves slowly. The transmission starts just as the stylus moves away from its zero position, and the stylus marks the recorder paper the instant the echo returns. The depth scale, reading in feet, extends across the recorder chart. Position of the trace, read against this scale, provides target depth.

Assume that you are alternately working two submarines, both at the same depth (300 feet). One submarine is at long range; the other is in close. For the distant submarine the depression angle is small and stylus travel is slow. But it travels for a relatively long time before the echo prints. For the nearby submarine, AT THE SAME DEPTH, depression angle is large, and the stylus moves rapidly for a short time before the echo prints. Both echoes print at the same distance from the starting position of the stylus; that is, below the 300-foot depth mark on the depth scale.

There are only two controls on the depth recorder: sensitivity control and main switch.

The sonar computer-recorder group synchronizes the pulse transmission of both azimuth and depth sonars. The two sonars are keyed when the range recorder stylus is at zero.

EXPANDED SCALE CONTROL UNIT

When depth sonar is used for shallow, small-object search, the depth recorder main switch is turned to the EXPANDED SCALE position. Stylus speed is increased by 10 by increasing the voltage 10 times for a given depression angle. Instead of recording depths from 0 to 1500 feet, the depth scale records depths from 0 to 150 feet.

SUMMARY

Here, in review, is what the sonar computer group does:

1. Controls the depth-determining sonar stylus speed so that the true target depth can be measured accurately.

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2. Synchronizes pulse transmission of the two sonar installations, and directly controls keying and recorder clutch action of the depth-determining equipment.
3. Provides aided tracking to the depression controls of the depth-determining equipment.
4. Records the audio output of azimuth echo-ranging equipment in such a manner that target range can be read from a chart.
5. It computes the HORIZONTAL range of the sonar target and transmits it to fire control instruments.

ROUTINE CHECKS

Although the computer-recorder group is used only during sonar contact, it must be ready for immediate use when the ship is underway. During cruising watches the main switches of the range and depth recorders are kept at standby, unless you have a specific order to the contrary. In the standby position the equipment is ready for operation 5 seconds after the switches are turned on.

To be sure the equipment is operating properly, the following routine checks should be conducted once a day in port and at the beginning of each watch at sea.

Chart Paper

See that the chart paper supply in both depth and range recorders is adequate. Appearance of a blue line in the center of the chart indicates only 6 feet of paper remain, and a new roll should be inserted. Directions for replacing paper are contained in the manufacturer's instruction book. Each step is illustrated.

Range Recorder

To check the range recorder, turn the azimuth search sonar on (it will be in standby in port), and the attack director switch off. Be sure that the *dRq* OFF–TEST switch and the depth recorder test switch are off, and that the

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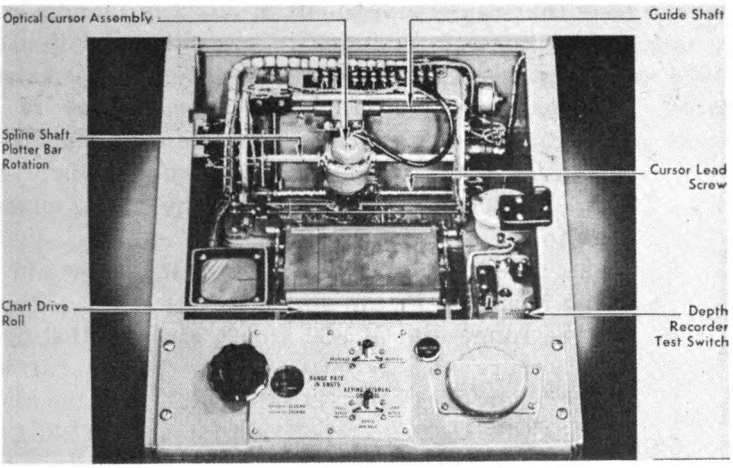

Figure 9–6.—Range recorder, top view.

test microswitch is disengaged from the cam. (See fig. 9–6.) Put the keying interval control in RANGE VARIABLE position. Perform the following tests:

1. Slew optical cursor assembly with RANGE lever. Cursor assembly should travel to the right in the INCREASE position and to the left in the DECREASE position.
2. Manual correction handwheel control moves cursor assembly to the right when turned to the right and to the left when turned to the left.

   NOTE.—Limit switches stop the mechanism at zero and 3750 yards range. It is then possible to increase range from zero and decrease range from 3750 yards by means of the slewing control only.
3. Operate RANGE RATE control and note that cursor image on chart rotates in a counterclockwise direction when dial is turned to solid portion of scale, and in a clockwise direction when dial is turned to dotted portion of scale.

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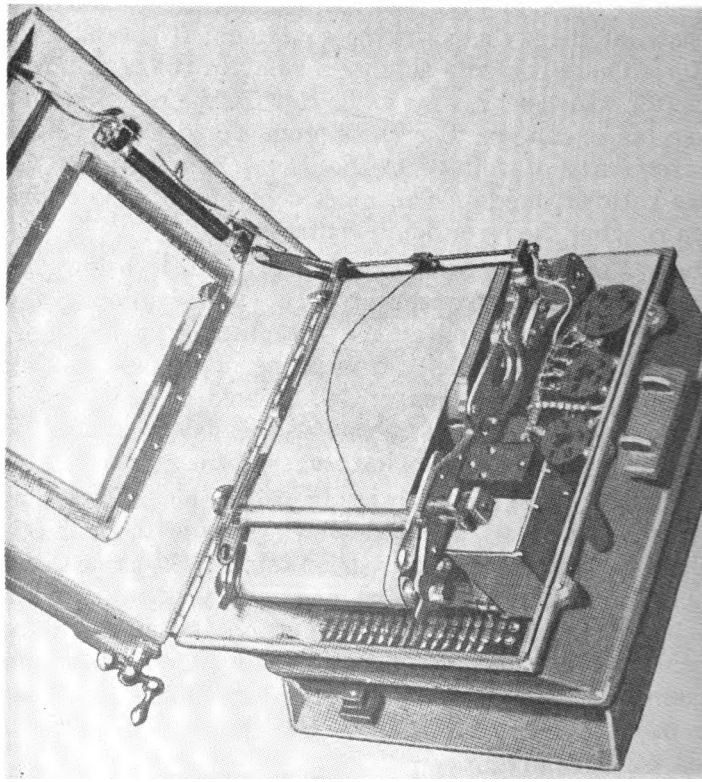

Figure 9–3.—Horizontal range recorder.

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RECORDING RANGE

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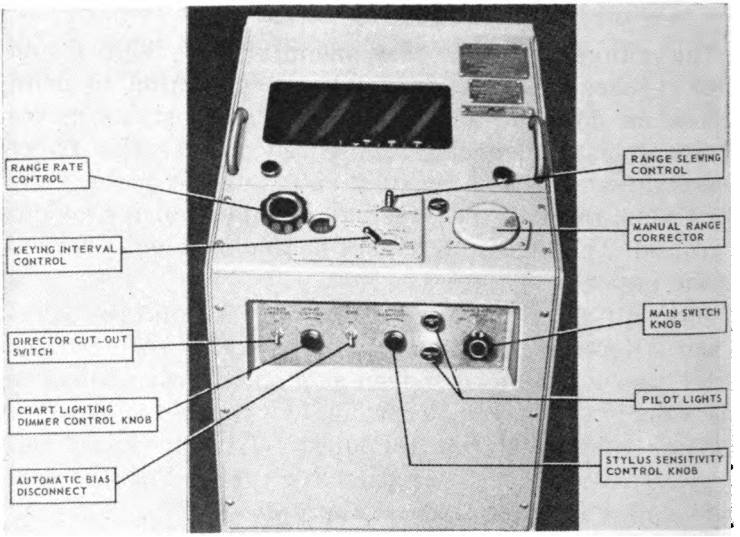

Figure 9–4.—Range recorder.

faster the cursor moves toward the left. In normal operation, the keying interval also shortens as the range decreases, just as it does when you bring in the flyback on a conventional tactical range recorder. The stylus returns after passing a short distance (about 200 yards) beyond the cursor line.

Keying Interval Switch

Look again at figure 9–4. This time notice the keying interval switch. It has three positions—center, left, and right—labeled RANGE VARIABLE, FULL SCALE, and LONG SCALE.

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Front Panel

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DEPTH RECORDING

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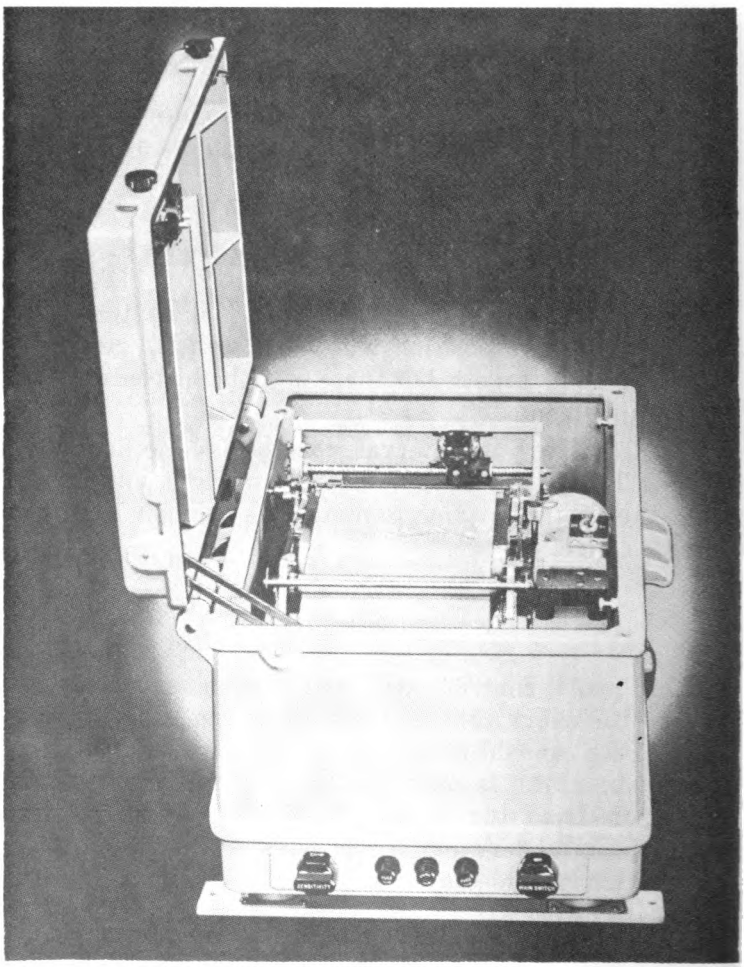

Figure 9–5.—Depth recorder with top cover raised.

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steep, the stylus moves rapidly from left to right; if the beam is nearly horizontal, the stylus moves slowly. The transmission starts just as the stylus moves away from its zero position, and the stylus marks the recorder paper the instant the echo returns. The depth scale, reading in feet, extends across the recorder chart. Position of the trace, read against this scale, provides target depth.

Assume that you are alternately working two submarines, both at the same depth (300 feet). One submarine is at long range; the other is in close. For the distant submarine the depression angle is small and stylus travel is slow. But it travels for a relatively long time before the echo prints. For the nearby submarine, AT THE SAME DEPTH, depression angle is large, and the stylus moves rapidly for a short time before the echo prints. Both echoes print at the same distance from the starting position of the stylus; that is, below the 300-foot depth mark on the depth scale.

There are only two controls on the depth recorder: sensitivity control and main switch.

The sonar computer-recorder group synchronizes the pulse transmission of both azimuth and depth sonars. The two sonars are keyed when the range recorder stylus is at zero.

EXPANDED SCALE CONTROL UNIT

When depth sonar is used for shallow, small-object search, the depth recorder main switch is turned to the EXPANDED SCALE position. Stylus speed is increased by 10 by increasing the voltage 10 times for a given depression angle. Instead of recording depths from 0 to 1500 feet, the depth scale records depths from 0 to 150 feet.

SUMMARY

Here, in review, is what the sonar computer group does:

1. Controls the depth-determining sonar stylus speed so that the true target depth can be measured accurately.

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2. Synchronizes pulse transmission of the two sonar installations, and directly controls keying and recorder clutch action of the depth-determining equipment.
3. Provides aided tracking to the depression controls of the depth-determining equipment.
4. Records the audio output of azimuth echo-ranging equipment in such a manner that target range can be read from a chart.
5. It computes the HORIZONTAL range of the sonar target and transmits it to fire control instruments.

ROUTINE CHECKS

Although the computer-recorder group is used only during sonar contact, it must be ready for immediate use when the ship is underway. During cruising watches the main switches of the range and depth recorders are kept at standby, unless you have a specific order to the contrary. In the standby position the equipment is ready for operation 5 seconds after the switches are turned on.

To be sure the equipment is operating properly, the following routine checks should be conducted once a day in port and at the beginning of each watch at sea.

Chart Paper

See that the chart paper supply in both depth and range recorders is adequate. Appearance of a blue line in the center of the chart indicates only 6 feet of paper remain, and a new roll should be inserted. Directions for replacing paper are contained in the manufacturer's instruction book. Each step is illustrated.

Range Recorder

To check the range recorder, turn the azimuth search sonar on (it will be in standby in port), and the attack director switch off. Be sure that the *dRq* OFF–TEST switch and the depth recorder test switch are off, and that the

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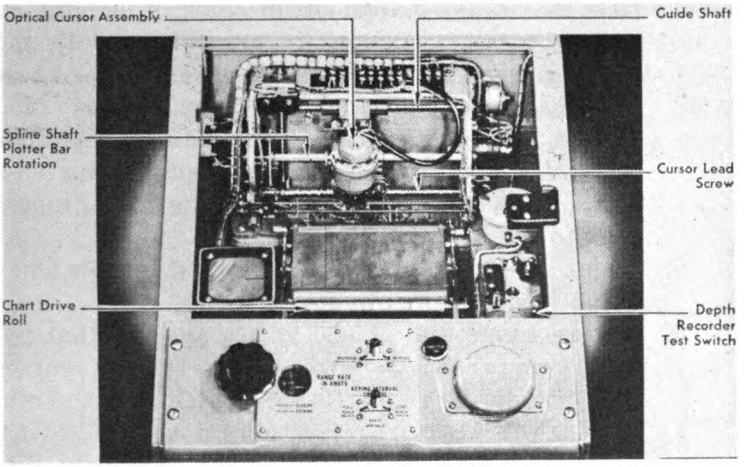

Figure 9–6.—Range recorder, top view.

test microswitch is disengaged from the cam. (See fig. 9–6.) Put the keying interval control in RANGE VARIABLE position. Perform the following tests:

1. Slew optical cursor assembly with RANGE lever. Cursor assembly should travel to the right in the INCREASE position and to the left in the DECREASE position.
2. Manual correction handwheel control moves cursor assembly to the right when turned to the right and to the left when turned to the left.

   NOTE.—Limit switches stop the mechanism at zero and 3750 yards range. It is then possible to increase range from zero and decrease range from 3750 yards by means of the slewing control only.
3. Operate RANGE RATE control and note that cursor image on chart rotates in a counterclockwise direction when dial is turned to solid portion of scale, and in a clockwise direction when dial is turned to dotted portion of scale.

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4. Note that range dial to left of chart is illuminated and that range changes in accordance with the slewing (controlled by RANGE lever) and decreases steadily when you apply a closing range rate. Change the range to 1300 yards and note that optical cursor is toward the right of the chart. Increase range to 1800 yards and note that the cursor moves back to the center of the chart.
5. Stylus speed should change from fast to slow when range is changed as in step 4.
6. Set the range dial at 800 yards, and see that flyback occurs shortly after stylus passes cursor image when KEYING INTERVAL switch is in the center (RANGE VARIABLE) position. Move KEYING INTERVAL switch left to FULL SCALE, and note that flyback occurs at full scale. Move KEYING INTERVAL switch right to LONG SCALE. Flyback should remain on full scale, stylus excursion rate should slow to long scale, and cursor assembly should move to a range of 375 yards.
7. AN/SQA–4 (OKA–1) should control keying of the azimuth search sonar. Azimuth sonar should key as range recorder stylus excursion starts.
8. With signal BIAS switch off, adjust STYLUS SENSITIVITY control so that signals from the azimuth system equipment mark the chart without excessive burning. Turn signal BIAS switch on and note that reverberation traces decrease in intensity.
9. Check operation of CHART LIGHTING dimmer control.
10. Slew to 1200-yard range and allow transmission traces to form along several inches of chart. Turn RANGE RATE control to zero, and slew down scale to exactly zero range on the dial. Use manual correction to get exact zero.

    NOTE.—Limit switches stop the mechanism at zero and it is possible to increase range from zero only with the slewing control. It is then

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possible to reduce range carefully by manual correction. The zero range limit switch may be set to operate at a range greater than exact zero. If so, it will not be possible to reach exact zero without disabling the zero range limit switch.

Depth Recorder

To check depth recorder operation, turn on both depth and range recorders. Next, turn on azimuth search and depth sonars. Observe that—

1. Depth recorder stylus is keyed by range recorder.
2. Depth recorder records audio output of the depth sonar.
3. Optical cursor image of depth recorder is perpendicular to stylus travel.
4. Depth recorder optical cursor image lies about 1/32 of an inch to the left of the left edge of the transmission traces when the cursor assembly is against its stop screw.
5. Speed of stylus travel increases with an increase of depression angle (*Eq*).
6. Speed of stylus travel increases after layer depth contacts are closed by stylus.
7. Placing depth recorder main switch in expanded scale causes stylus to travel at a rate approximately 10 times normal rate and at a constant rate for entire scale excursion.

Sonar Data Computer

Open the sonar data computer cabinet door and note the response when you manipulate controls of range and depth recorders in the tests below.

1. Set recorder range dial to zero. The *Rq* dial on the sonar data computer range mechanism should indicate exact zero. If you change the range dial setting, the *Rq* dial should track it.

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2. Set optical cursor assembly against its stop screw at the extreme left end of its travel. The *H'q* dial on the depression angle mechanism should indicate exact zero. If you change the position of the cursor assembly, the *H'q* dial should track it.
3. Manipulate depression control of the depth sonar. The *Eq* dial on depression angle mechanism should track depression angle as indicated by the depth sonar depression dial.
4. Set *Rhq* dial to 100 yards. Set *H'q* dial to 300 feet. The *cEtq* dial should read exactly 45°. A change in setting of either *Rq* or *H'q* should cause a change in *cEtq*. A decrease of *H'q* with *Rq* held constant will decrease *cEtq*.
5. Set range rate control to closing rate of 10 knots. The $\triangle cEq$ dial will rotate in a clockwise direction and the *Eq* dial will move through 10° of rotation per one revolution of the $\triangle cEq$ dial.

If any of the controls fail to operate, or if the response from the equipment does not match the requirements of the test, make a report to the sonar supervisor. Corrective maintenance for the equipment is contained in the manufacturer's instruction book, NAVSHIPS 91672(A) for AN/SQA–4, and NAVSHIPS 91333(A) for OKA–1.

TUBE REPLACEMENT

Tubes of the same type, manufactured by the same company, may vary slightly in operating characteristics. The various circuits of the OKA–1 and SQA–4 have been so designed that the equipment is pretty much independent of these tube variations. For that reason it isn't important that you match exactly the characteristics of a tube you are replacing. Just be sure you replace it with a tube having the same type number as the original.

LUBRICATION

The sonar computing group is a system of complex synchros and precision motors which, for the most part,

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have been adequately lubricated during manufacture. It is a good practice to leave them alone as much as possible. Portions of the range and depth recorder mechanisms require periodic lubrication. As a general practice, the sonar supervisor details equipment checkout and lubrication duties to his men for specified periods of time. You may be on the SQA–4 or OKA–1 for a month and then rotate to the TRR or azimuth search sonar. As you gain experience, you will receive more difficult and complex maintenance assignments.

All maintenance, including lubrication, should be performed as outlined in the manufacturer's instruction book, or maintenance checkoff sheets based on manufacturer's requirements. Lubrication charts in the manufacturer's instruction books specify the type of lubricant, frequency of use, and illustrate the parts to be lubricated. Where it is necessary to remove components to gain access to parts of the equipment requiring lubrication, the instruction book describes access procedures.

FUSE FAILURE

Tables in the instruction books for SQA–4 and OKA–1 give the location of each fuse in components of the computer-recorder groups, and list symptoms that will help you detect fuse failure. No special test equipment is needed to observe these symptoms. Generally you can tell that a fuse has blown by looking at it. The rule is: Never replace a fuse with one of a higher rating unless continued operation of the equipment is more important than probable damage. If a fuse burns out immediately after replacement, don't replace it a second time until you correct the cause of the trouble.

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QUIZ

1. What is the primary function of the computer-recorder group?
2. What is the definition of each of the following terms?
   (a) *Rq.* (b) *Rhq.* (c) *Eq.* (d) *Eqr.* (e) *H'q.*
   (f) *Pvq.* (g) *Hq.* (h) $\triangle V$.
3. How many positions does the keying interval switch provide?
4. What unit synchronizes the pulse transmission of both azimuth and depth sonars?
5. What should be done when a blue line is seen on the center of the recorder paper?
6. How often should routine checks be performed?

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CHAPTER 10

RECORDER TRACES

OPERATING TECHNIQUE

The recorder is a weapon just as a battleship's big guns and the strong right arm of a man are weapons. To use it against the evading tactics of submarines, you must know your equipment and be able to decide what the submarine is doing by correctly interpreting the recorder traces. This requires technique and knowledge. You will gain your knowledge by carefully studying this book but you must practice with the recorder to develop good operating technique.

All the mechanics of operating the recorder—reading range and range rate, handling the controls—should become automatic to you so that you can devote your attention to interpreting the traces. You must also pay careful attention to the sounds coming from the loudspeaker at the same time you are observing the marks appearing on the recorder tape. EACH MARK MUST BE EVALUATED ON THE BASIS OF THE SOUNDS ACCOMPANYING IT.

SEARCHLIGHT AND AZIMUTH SEARCH

Recorder traces provide the same information, whether the recorder operates with searchlight or azimuth search sonar. In either case, length of trace is determined by length of outgoing signal (pulse length), and length of

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reflecting surface (the target). Heaviness of the trace depends on the strength of the echo; the more energy that returns as an echo, the heavier the trace. Echo strength depends on the range and size of the target, sonar gain setting, and thermal conditions.

Although traces from both types of sonar provide essentially the same information, there is some difference in the way they print on recorder tape. With searchlight equipment the pulse length prints at the start of the recorder stylus excursion. With scanning sonar, the TVG feature suppresses the pulse, and only the echo prints. When scanning sonar has contact, a trace prints with every transmission. When searchlight has contact, the traces print in groups because the operator, even if using BDI, must get off the target to take right and left cut-ons.

Trace characteristics are more pronounced with searchlight sonar than with azimuth search. In other words, searchlight, though obsolete, provides more trace information than scanning and is easier to interpret.

TARGET ASPECT

Target aspect tells whether the submarine is heading toward or away from its transducer. By interpreting the recorder traces skillfully, you can determine the target aspect and thus provide the conning officer with important information for the attack.

So that you may report information more conveniently, the target aspects have been divided into five groups, which you can see in figure 10–1.

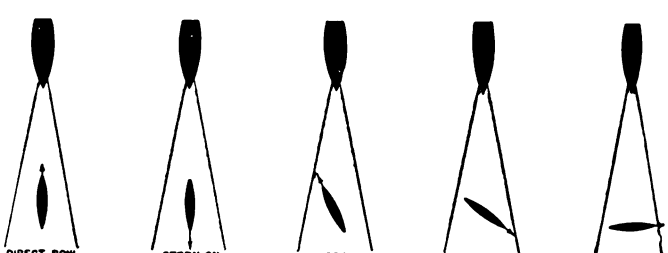

Figure 10–1.—Five groups of target aspects.

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These five standard target aspects are—

1. The direct-bow target.
2. The stern-on target.
3. The bow target.
4. The quarter target.
5. The beam target.

Beam Target

When the target is headed at approximately right angles to the beam of sound projected against it, it is called a beam target. In other words, you are echo ranging from directly abeam of the target and it is headed neither toward nor away from you. When own ship is headed directly at the target, your course will be at right angles to the target's course.

Quarter Target

When the target is headed at an angle away from your sound beam, you call it a quarter target. In this case, you are echo ranging from a position on the target's quarter.

Bow Target

When the target is headed toward the sound beam at an angle, it is called a bow target. This time you are echo ranging from a position on the target's bow.

Stern-On Target

When the target is headed directly away from the sound beam, it is a stern-on target. You are echo ranging from dead astern of the target.

Direct-Bow Target

When the target is headed directly toward you, it is a direct-bow target. You are echo ranging from a position dead ahead of the target. All of these target aspects are

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independent of the heading of your own ship. They depend solely upon the heading of the target in relation to the sound beam.

Range Rate vs. Target Aspect

When you are heading at the submarine, range rate also tells you whether the submarine is coming toward or going away from your ship. You may be wondering why target aspect should have such importance during an antisubmarine attack.

Range rate is useful only when you compare it with own ship's speed, and it is difficult to know just how fast your ship is going. The state of the sea and the wind will affect your speed, and when you change course your speed is somewhat lessened. Furthermore, if you aren't heading directly at the sub, the range rate will be unreliable. So you must have some other source of information about the aspect of the target. Your two best sources are recorder traces and doppler.

Doppler and Recorder Traces

Doppler and recorder traces work together serving as a check for one another. That's why it's essential for you to use your eyes and ears at the same time. When you're operating the recorder, look at the traces and listen to the doppler from the loudspeaker. If you hear no doppler, you should have a beam trace. Doppler high means a bow or direct bow target, and doppler low means a quarter or a stern-on target.

Individual Echoes

Think of your outgoing signal as a disk of sound with thickness determined by the pulse length. (Pulse length of AN/SQS 10 and 11 equipment, you will recall, may be 6, 30, or 80 milliseconds.) The longer the pulse, the thicker the disk. As it travels out, the pulse length remains the

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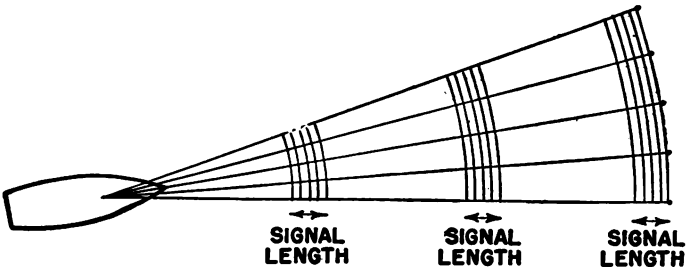

Figure 10–2.—The signal length doesn't change.

same; the sound gets wider, but not thicker. The signal is the same at the end of its journey as it was at the beginning, when it left the transducer. (See fig. 10–2.)

Now suppose this disk of sound hits a submarine which is beam-on to the sound beam. All parts of the outgoing disk will strike the submarine at the same time and therefore all parts of the disk will be reflected and started on their return journey AT THE SAME TIME. In figure 10–3, you can see that parts 1, 2, 3, and 4 will start back at the same time.

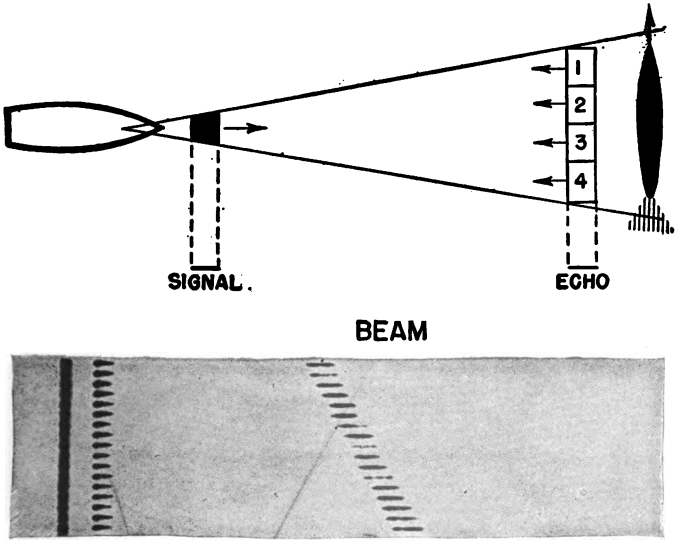

Figure 10–3.—The echo and signal are the same length.

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These will hit the transducer at the same time, and when this returning echo reaches the receiver, it will be transformed into a short dark line on the recorder tape. THIS TRACE WILL BE THE SAME LENGTH AS A RECORDED PULSE LENGTH.

The beam trace will have no doppler and it will have a definite "smack" as you hear it. It sounds short and sharp, and it appears on the tape very much as it sounds. Both edges of the trace are sharp and distinct, and the whole trace is solid and well defined. It is very easy to recognize and is the simplest of recorder traces. Study figure 10–3 until you can recognize it easily.

Consider the case of the quarter target that is shown in figure 10–4. Since the stern of the sub is nearer than the bow, that part of the beam marked 1 will hit the sub first and start back first. It will be followed by the part marked 2, and so on.

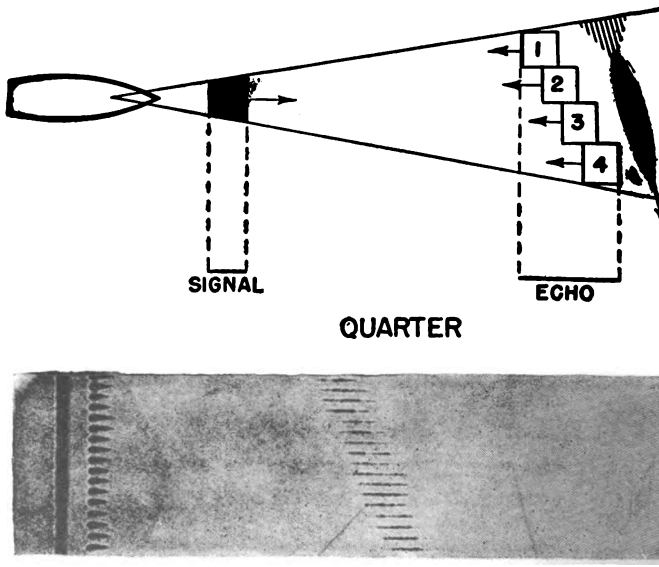

Figure 10–4.—The echo is longer than the signal.

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As you can see, part 1 will return to the transducer much sooner than the part marked 4, and therefore this echo will be recorded as a long trace. Because the trace is drawn out, it will not be as clear as a beam trace. The ends are not clearly defined. At long range the trace may be weak but you can distinguish it by the LOW DOPPLER that accompanies it.

If you have a stern-on target, the trace will be similar to a quarter trace as you can see in figure 10–5. But on a stern target some of the echo will return from the wake, some from the stern, some from the conning tower, and some from the bow. This will tend to make the echo even longer than the quarter target. It will not be as solid as the quarter trace but will be very long.

Stern traces will also be irregular and may vary in shape and length from echo to echo. The doppler is low and the left edge of the trace may be particularly irregular because of the wake.

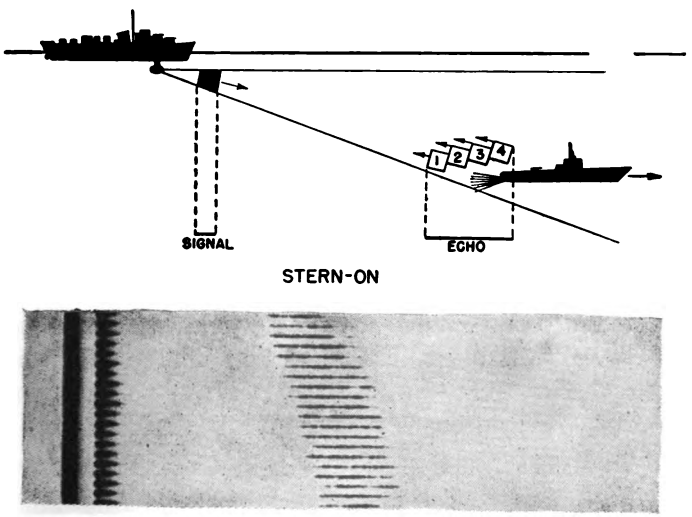

Figure 10–5.—This is the longest type of sub echo.

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The bow target traces, shown in figure 10–6, will be longer than the outgoing traces. That part of the beam that hits the bow will return ahead of the part that hits the stern. So, the echo will be lengthened. You'll hear high doppler.

If the sub is coming directly toward your sound beam, the trace will be direct-bow, as it is in figure 10–7. Again the trace will be very long because the echoes are returning at different ranges from various parts of the sub. The traces may be very weak until you are at short ranges, when they will begin to appear more clearly. Direct-bow traces are fairly irregular especially at the right edge because of the wake effect. But the wake will not be as prominent as in stern cases inasmuch as it is farther away than the sub itself. The doppler will be high.

HOW TO IDENTIFY A TRACE

The best way to identify a recorder trace is to decide first if it is a beam trace. You will have the printed pulse for comparison in searchlight equipment—beam trace and printed pulse will be the same length. You can't make this comparison with azimuth search equipment, but you will find with experience the beam trace is easily recognized.

With the first traces, listen for doppler. If doppler is low, the target is either quarter or stern-on. If high, the target is either bow or direct-bow.

Searchlight sonar provides further identification of bow and quarter traces. Wake loops or waviness, which may not appear until short range, are typical of bow and quarter traces from searchlight. If traces remain long without loops, the target is stern-on or direct-bow. Azimuth search traces are never accompanied by loops, and the long traces are not as long as the return from searchlight. Azimuth search traces are always shorter than searchlight traces because the pulse length is shorter.

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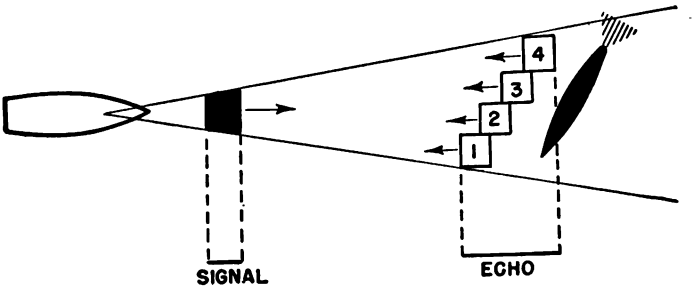


BOW

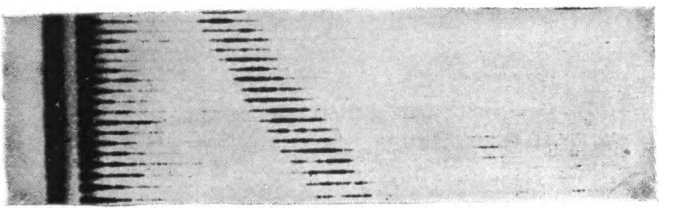
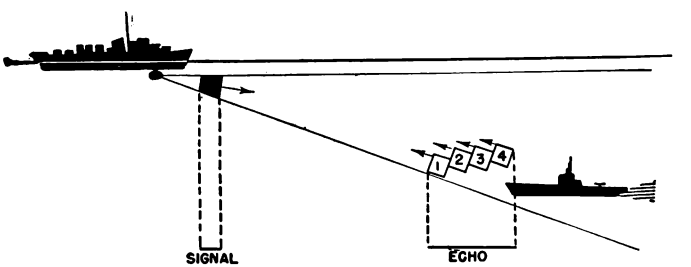


Figure 10–6.—The echo is longer than the signal.



DIRECT BOW

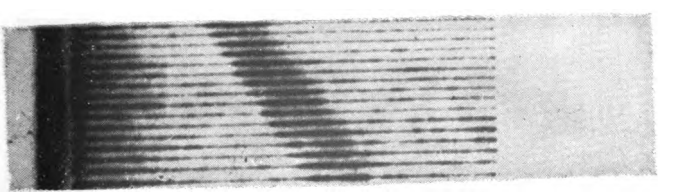


Figure 10–7.—Listen for high doppler.

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CUTS AFFECT RECORDER TRACES

When a searchlight operator crosses the target and reports cuts, the traces develop a certain pattern that is different for each type of target aspect.

Look at the quarter target in figure 10–8B. The range to the bow of the sub is longer than the range to the wake and the stern. Therefore, the bow cut will record at a longer range than the wake and stern cuts. The trace develops a wavy aspect, which is characteristic of bow

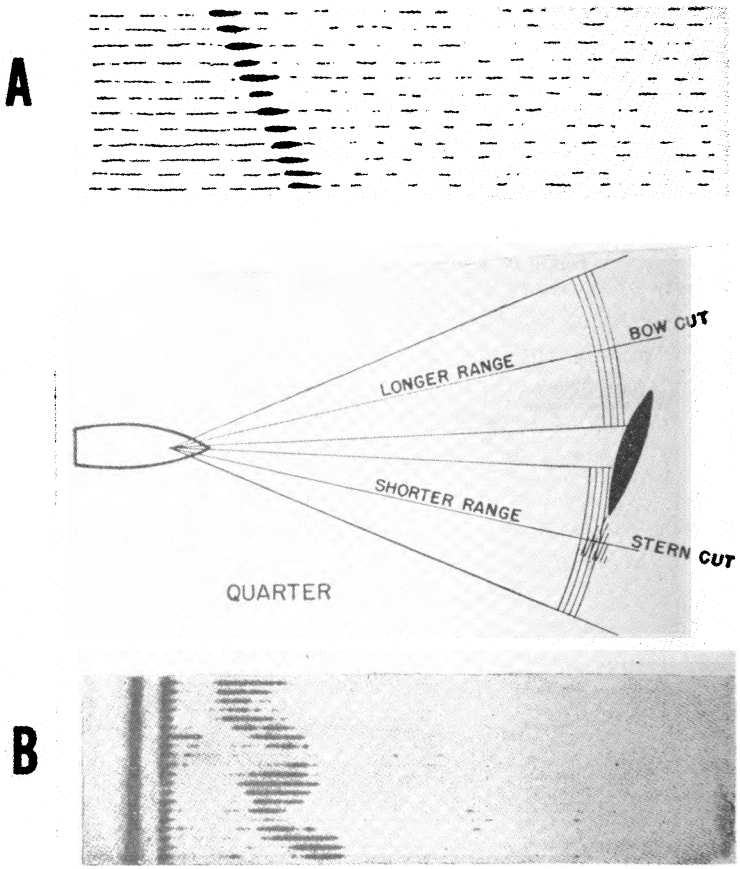

Figure 10–8.—The stern is nearer than the bow.

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or quarter target. In either case, one end of the submarine is at shorter range than the other. If target speed is enough to produce significant wake traces, they show to the left of the target traces for a quarter target and to the right for a bow target. Also, they are pronounced for the cut on the stern of the target and invisible on the opposite cut. The wavy characteristics of the trace appear only during cut-on procedure. If the operator is using azimuth search sonar or is following BDI procedure, you will not see these wake loops. They are not present in azimuth search sonar traces because the operator never trains off target when tracking.

Notice that the scanning traces in figure 10–8A are long, continuous, with even edges and no waviness. Much can be learned from the length of the trace alone.

When the searchlight sonar operator trains off the stern-wake end of the target, he will hit the no doppler wake echo. This echo is from a shorter range than the submarine echo and helps to form the loops on the left side of the traces. When the operator goes off the bow end of the target, there will be no echo and therefore no trace. So the wake cuts form loops at shorter range and the bow cuts form a smooth edge on the right side of the trace. ALWAYS USE THE SMOOTH RIGHT EDGE OF THE QUARTER TRACE FOR LINING UP THE PLOTTER BAR FOR RANGE RATE. If you use the left edge, you will have a false picture of the position of the submarine.

You have just the opposite case in a bow aspect. In figure 10–9 you can see that the bow of the submarine is nearest the transducer and therefore will form the left edge of the trace or the short-range side of the trace. The wake and stern of the submarine are farthest away and they will be on the far side of the trace which is the right side. The left edge will be smooth, as it is from the bow. The wake will cause the right edge of the trace to be wavy. LINE UP THE PLOTTER BAR WITH THE LEFT EDGE OF THE BOW TRACE WHEN YOU WISH TO OBTAIN RANGE RATES.

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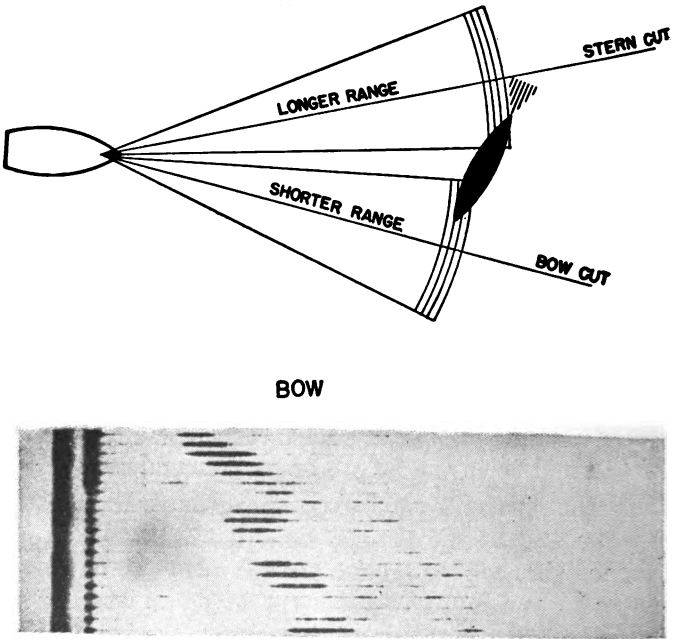

Figure 10–9.—The bow is at shortest range.

As the range closes, the waviness of the bow and quarter traces becomes more pronounced when CUT-ON procedure is used. Listen to the console operator as he calls right and left cuts, and try to decide, from the appearance of your traces and from the doppler, which cut is the bow cut and which cut is the stern-wake cut. If you hear him call "Left cut," at the same time you see a BOW CUT TRACE, then you know the bow is the left side of the submarine and that the target is moving to the left. Then you would expect the right cut to be the stern-wake cut.

With practice, you can listen to the console operator and the doppler at the same time you are interpreting the traces. Decide from the appearance of the traces which edge represents the bow and which edge is the stern-wake.

The wake is always at the stern of the sub. If the wake appears to the right, the target is moving left. If it ap-

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pears to the left, the target is moving right. This information is particularly important on short-range attacks when there isn't time to figure out which way the sub is going.

Figure 10–10 illustrates two examples of stern-on target traces. Notice the wake traces to the left of the target in the azimuth search example. The right edges of the target are even and clearly defined. The left edge is confused because the beam is striking the submarine through wake. There is no doppler. USE THE RIGHT EDGE OF STERN-ON TRACES TO OBTAIN RANGE RATES.

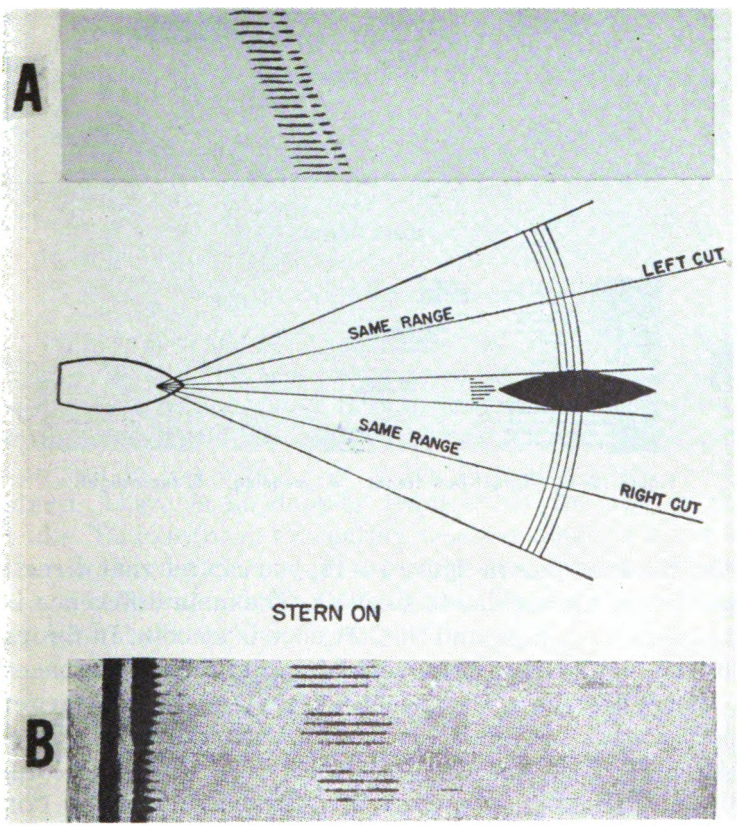

Figure 10–10.—Stern-on traces. A. scanning; B. searchlight.

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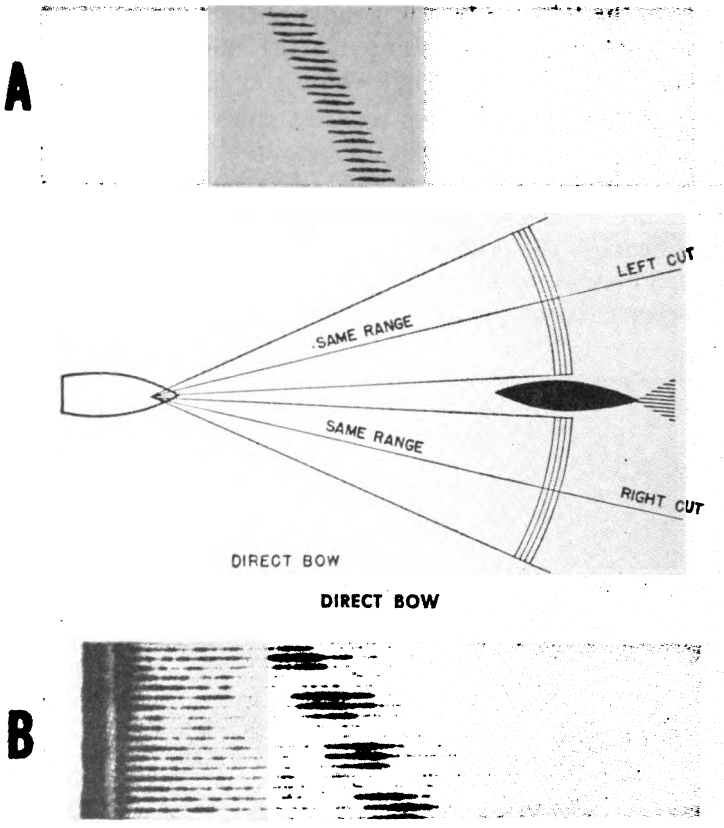

Figure 10–11.—Direct-bow traces. A. scanning; B. searchlight.

In the examples in figure 10–11, you can see that direct-bow traces are similar to stern-on. The main difference is that doppler is high and the left edge is smooth. In figure 10–11A, notice that heaviness of target traces increases as range decreases. Early echoes from a direct-bow target may be weak and there may be no traces until short range. Listen for high doppler and expect weak traces at long range. USE THE LEFT EDGE OF DIRECT-BOW TRACES FOR RANGE RATE.

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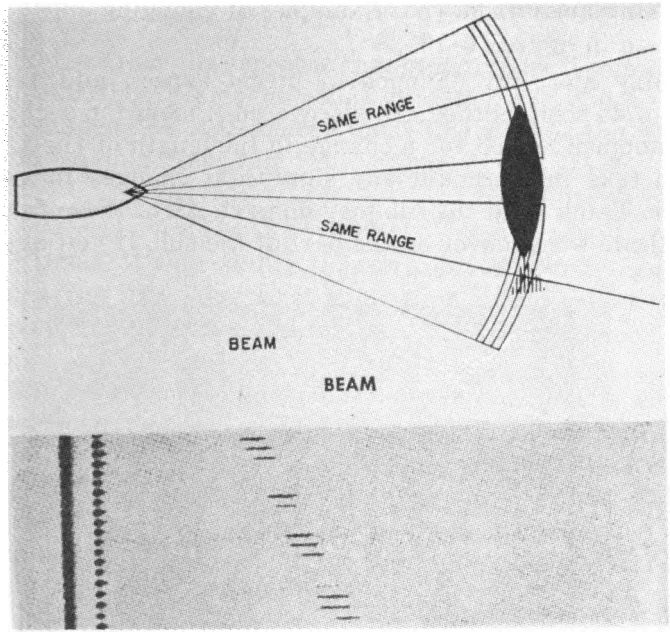

Figure 10–12.—This is easy to recognize.

The beam target is a clear-cut smooth trace as shown in figure 10–12. The bow, stern, and wake are about the same distance away, and you can read the range rate from either side of the smooth beam trace. It may be difficult for you to tell which side is the bow and which is the stern. There is no doppler from either the sub or the wake. Be careful in estimating whether a sub is going to the right or left in a beam aspect. A slow or deep sub may leave little wake, and a fast sub may leave a wake that is difficult to distinguish from the sub.

WHEN ASPECTS CHANGE

Once a submarine has been discovered, it may use any number of evasive tactics to escape your weapons. One of the best ways you have of knowing these tactics is the recorder trace. For instance, if the target aspect changes from beam to quarter, you know that the submarine is

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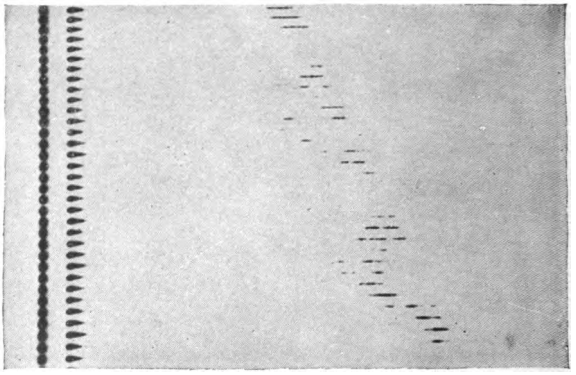
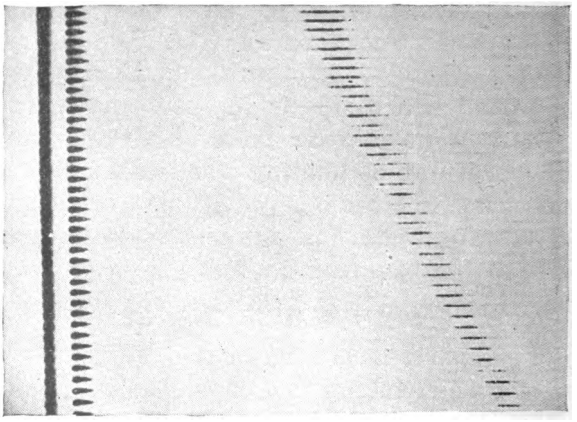
turning away from you. Examples of changing aspect are shown in figure 10–13.

Stay alert for changes in target aspect, and report them as soon as they are discovered. Listen for a change in doppler, watch for a change in the length of the trace, and take into account any significant changes in range rate. Think what the sub may do next. All of these factors indicate a maneuver on the part of the sub. If you are do-



CUTS - QUARTER TO BEAM



BDI - BEAM TO QUARTER

Figure 10–13.—Note difference between BDI and cuts.

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ing your job well, you will be the first to know the sub's tactics.

If you see that the aspect is changing, report it immediately, and then decide in which direction the change is being made. The A/S officer must know what the submarine is doing. Keep him fully informed.

FIRING TIME

The proof of your ability to interpret recorder traces is in the firing time. You must know what target aspect the traces represent before you can report the correct time for firing.

When the aspect is stern-on or quarter, the trace is wide because it is made up of echoes from both the sub's wake and the sub itself. You want to hit the submarine, not the wake. So you must fire when that part of the trace that represents the sub is under the firing bar. This point is ONE PULSE LENGTH in from the right side of the trace. It is illustrated in figure 10–14.

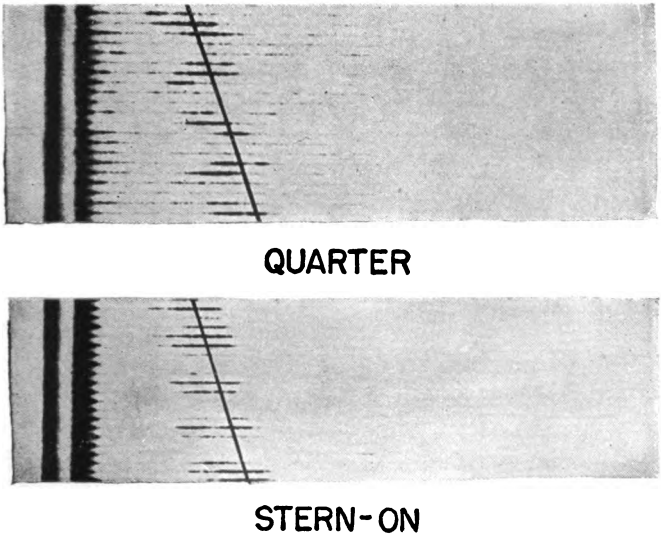

Figure 10–14.—Don't fire too soon.

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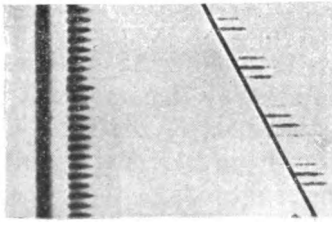
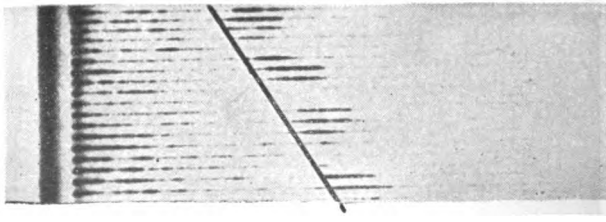
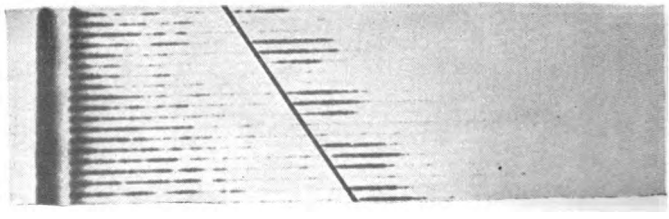
The left side of the trace in a stern-on or quarter aspect represents the wake and stern of the sub. Wait until this side of the trace has passed under the firing bar, and when a distance equal to ONE PULSE LENGTH remains to the right of the firing bar, call "Fire!" At this point—one pulse length in from the smooth right side of the trace—you have the correct range to the conning tower of the submarine. Remember to line up the range rate on the right side of a quarter or stern-on trace.



BEAM



BOW



DIRECT BOW

Figure 10–15.—Don't fire too late.

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In all other aspects—beam, bow, and direct bow—the wake is not between your ship and the sub, and therefore doesn't disturb the firing time. These cases are illustrated in figure 10–15. With these aspects, line up the range rate and report firing time from the left edge of the trace. This is the smooth edge and firing is very easy with these traces. Make sure you keep the range rate properly aligned, and fire when the leading edge of the trace hits the firing bar.

Here are your rules for firing:

1. Stern-on and quarter:
    a. Read range rate from the right edge.
    b. Fire and read ranges one pulse length in from the right edge.
2. Beam, bow, and direct bow:
    A. Read range rate and ranges from the left edge.
    b. Fire on the left edge.

NONSUBMARINE TRACES

You remember from chapter 4 that echoes are returned from other things in the water besides submarines. And everything that returns as an echo or makes a noise is traced as a line on the recorder tape when the recorder is operating. Occasionally, you should expect to see nonsub traces similar to those shown in figure 10–16.

The wake trace is characterized by no doppler, long individual echoes, and irregular waves and loops. You will notice, in figure 10–16, that the console operator did not move off this wake target. Target width probably was very great. Watch for wake traces and keep the console operator off the wake. Help him to stay on the sub by telling him which echo is the sub and which is the wake.

If another ship is transmitting on a frequency which is within 4 kilocycles of your own frequency, you are likely to hear its outgoing signals over your gear. The range at which these traces appear on your recorder is usually erratic, perhaps first appearing at 100 yards and at 1200

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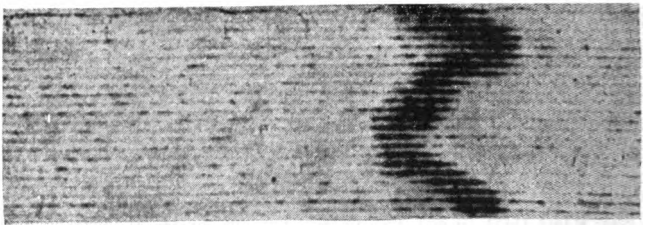
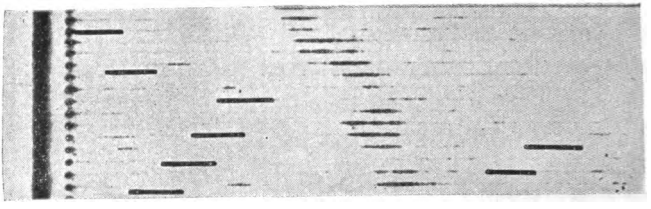
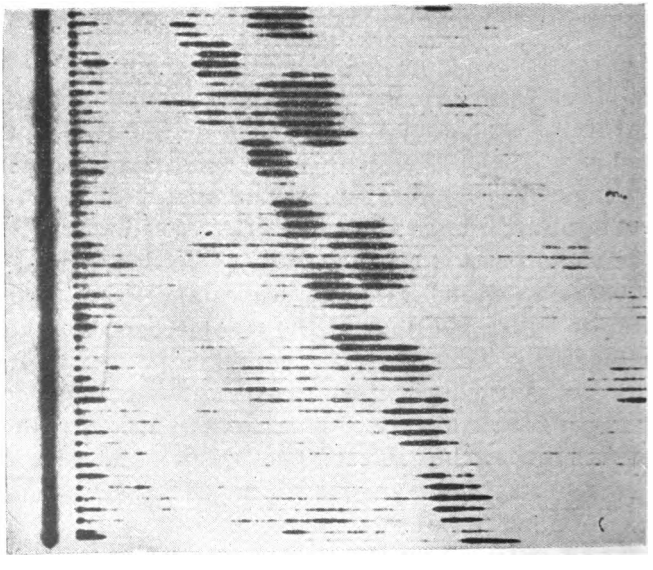


WAKE



INTERFERENCE



PILLENWERFER

Figure 10–16.—Nonsub traces.

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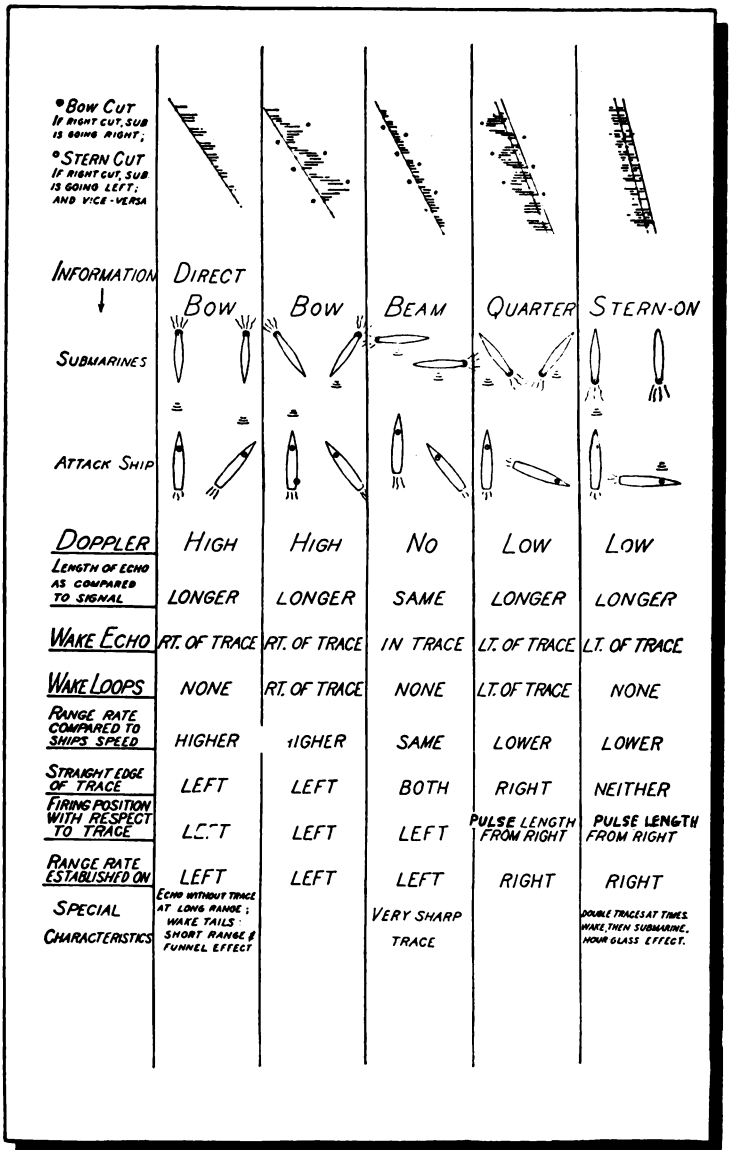

Figure 10–17.—Recorder trace interpretation.

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yards on the next trace. Sometimes they line up and form a pattern, sometimes they appear short, and other times long. If you want to verify this type of trace, stop keying and listen. If the sound keeps coming in while you are listening, it's not a submarine echo. Or if you prefer, send out two short signals, and if it's a sub echo, two signals should return to you.

A submarine operator can try to confuse you by transmitting with its own sonar gear. His transmission could appear as traces on your recorder.

Figure 10–17 is a summary of recorder trace interpretation.

PILLENWERFER

Pillenwerfer creates a mass of bubbles in the water which returns a loud, clear, sharp echo. This echo forms a very clear trace, similar to the trace of a beam on submarine. BUT THERE WILL BE NO DOPPLER. If high or low doppler suddenly changes to no doppler, be on guard against pillenwerfer. Concentrate on the echo that has doppler no matter how weak it is. Don't let the hoax of pillenwerfer lead you away from the true target. Listen to the doppler and check the range rate. Since the bubble target is motionless in the water, the range rate will be the same as your own speed.

If the sub turns sharply, it will leave a trace similar to pillenwerfer because an echo will return from the "knuckle" that the sub leaves in its wake when it turns. The knuckle trace will have a range rate equal to your attack speed, while the actual trace from the submarine will have a different range rate and will have doppler.

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QUIZ

1. What are the five standard target aspects?
2. Of what importance is doppler to the recorder operator?
3. Why does the trace from a stern target tend to be long?
4. What is the best way to begin the identification of a recorder trace?
5. If the wake appears on a right cut-on, in which direction is the sub moving?
6. As a rule of thumb, where do you line up the plotter bar when you have quarter or stern-on traces?
7. What are some of the characteristics of a wake trace?
8. If the sub creates a knuckle, what will be the range rate of the knuckle?

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CHAPTER 11

THE ATTACK PLOTTER

A PICTURE OF THE ATTACK

The attack plotter, known as the AP, is the "television" device of sonar gear. It gives you a visual picture of your ship's track, the submarine's track, your sound beam, and the range and bearing for a throwing attack. All of this is shown in spots of lights which appear on the screen of the cathode-ray tube. Figure 11–1 is an illustration of the attack plotter. Figure 11–2 presents a plan view, first of the scene of action, and second as it appears on the AP screen.

The AP screen is 12 inches in diameter (but only 10 inches are usable), and the plot is 250 yards to an inch. The width of the screen represents 3000 yards. At 15 knots, it would take a ship 6 minutes to cross this screen. The top of the screen is always true north, and the bottom —the part nearest you—is south. The plot is in true bearings.

Story Told With Lights

Own ship is represented by a spot of light which flashes automatically every time a ping goes out. These flashes leave a mark on the screen that you can see for about 2 minutes if the space in which the AP is being used is dark. This light records a visual track of own ship's movements.

The travel of the sound beam is shown by a small spot

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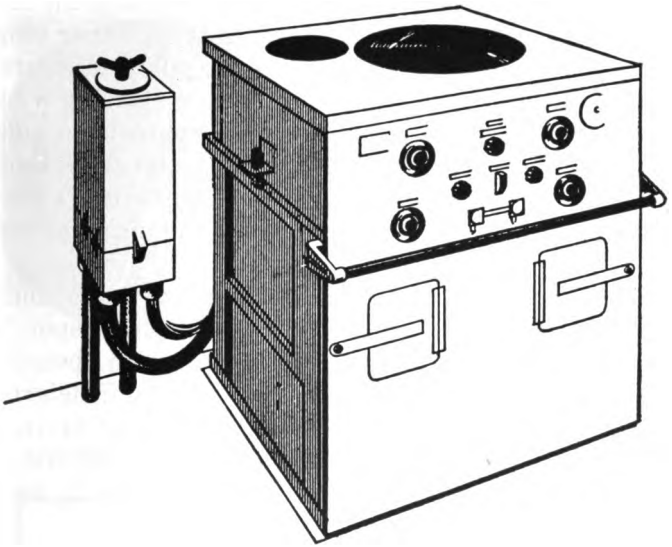

Figure 11–1.—The AP.

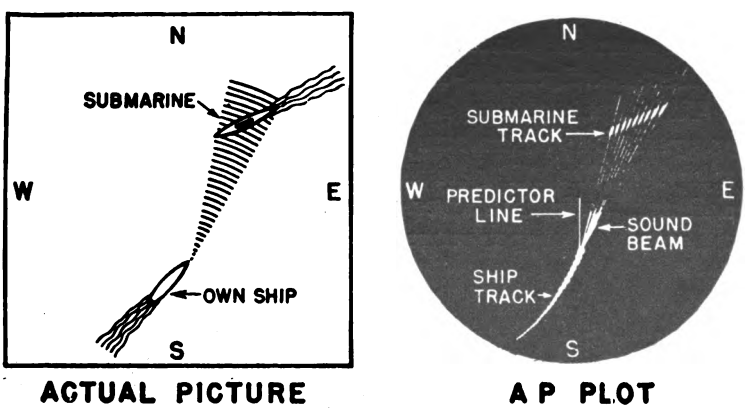

Figure 11–2.—The picture the AP gives.

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of light which moves out across the screen along the direction in which the cursor is trained. When another ping is sent out, the spot fades and automatically reappears at own ship's spot. Then it starts out again, leaving a faint trace behind it. When the sound beam contacts an object, and an echo is heard, the spot where the target is located brightens. A series of echoes from the target leaves a series of spots which shows you where the target has been and where it is.

There is one more line of light, called the PREDICTOR LINE, which may be flashed out from own ship's spot. You can adjust its length (range) and its direction (bearing). As you can imagine, this line of light is useful in determining the course to steer and the direction to train the hedgehogs. Because you can control the length of this line, you can tell when you are at the proper range to launch throwing weapons.

As in all the other sonar gear, you will receive echoes from things other than submarines. These echoes will appear as spots on the screen, and will give you a picture of the location of the echoes. If you ping on a wake, a spot will appear on the plot when the echo of the wake is heard. If you ping on the bow of the submarine, the spot shows you the location of the bow. The plot is simplified when it is used with scanning sonar because all the echoes will come from the center of the submarine. This point is illustrated in figure 11–3.

The attack plotter is fed information from the gyrocompass, the sonar equipment, and the dead reckoning analyzer. The AP gets this information from the DRA and automatically moves your ship's spot at the proper speed on the proper course.

JB SWITCH POSITIONS

It can be seen from figure 11–4 that the JB switch (located to left on bulkhead in fig. 11–1) has six positions. The purpose of each position is outlined on pages 222 and 223.

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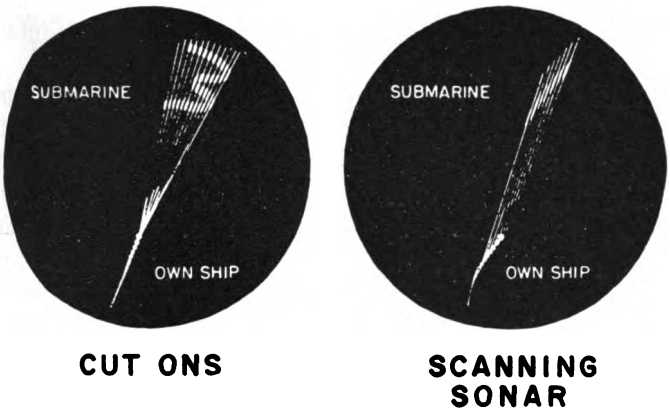

Figure 11–3.—Scanning sonar gives a narrower trace.

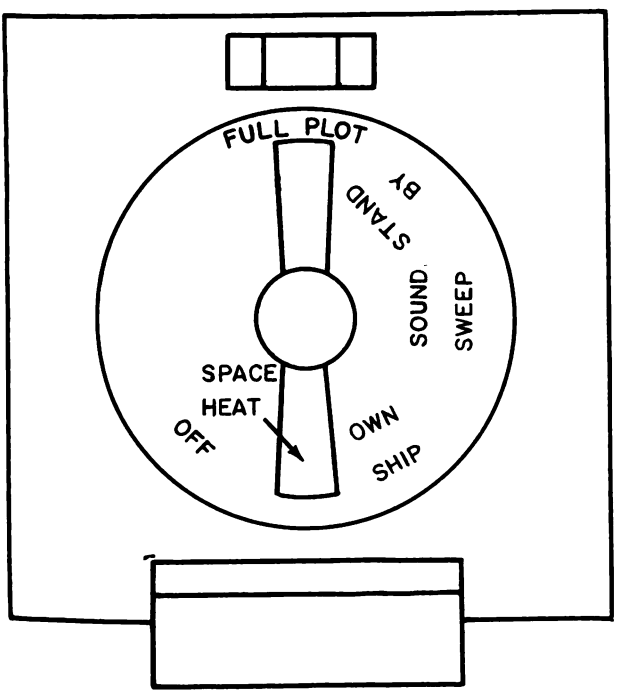

Figure 11–4.—Positions of JB switch.

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OFF.—In this position of the switch the instrument is completely disconnected from all other equipment and power supplies.

SPACE HEAT.—Ceramic insulated resistors, four in number, and designed to dissipate a total of 200 watts, are connected to the ship's 60-cycle power supply. Purpose of these heaters is to keep the inside of the instrument dry when not in use. These resistors are not connected in any other switch position. Space heaters should be used whenever some protection against cold or moisture is necessary. For extreme conditions, additional heater resistors could be wired in parallel to those provided. In tests, the attack plotter has been subjected to a temperature of 30° below zero centigrade (—22°F) for 24 hours without benefit of space heaters. It passed all operating tests immediately without a warmup period. The space heaters have been provided for additional security and to ensure longer life for the components.

OWN SHIP.—In this position of the switch the attack plotter is connected with the dead reckoning analyzer. Course of own ship is plotted on the screen. Sound sweep and echoes do not appear. This switch position is used when checking the course plot calibration of the attack plotter. Other applications for this limited type of operation may be developed where a large-scale plot of ship's course, for a short distance, is desired.

SOUND SWEEP.—In this position, the attack plotter is connected with the sound gear but is not connected to the dead reckoning analyzer. Sound sweeps and echoes can appear on the screen but the course of own ship is not included; own ship's position remains fixed. When an actual attack is not in progress the instrument may be used to observe the underwater sound search pattern without need for periodic repositioning of own ship. This switch position can be used when the sound sweep length is being calibrated.

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STANDBY.—In this position, the attack plotter is ready to operate, but is not connected to the DRA and sonar. The spot is stationary at the edge of the scope. Since a stationary spot may burn a hole in the screen, it must be kept dim. The edge chosen should be in the direction opposite the general direction in which the ship is moving. When contact is announced and the JB switch is turned to FULL PLOT, there is a better chance that the contact will appear on the screen without requiring adjustment of position controls.

FULL PLOT.—When you turn from STANDBY to FULL PLOT, complete operation will begin immediately. When you turn from some other position to STANDBY, there will be a short interval before the AP begins to function. In normal search, the JB switch should be on STANDBY; with contact, turn to FULL PLOT.

CONTROLS

Attack plotter controls are easy to use. Because you usually will operate the AP in a darkened space, you must practice until you can manipulate the controls without seeing them. Study figure 11–5; learn the name and location of each control.

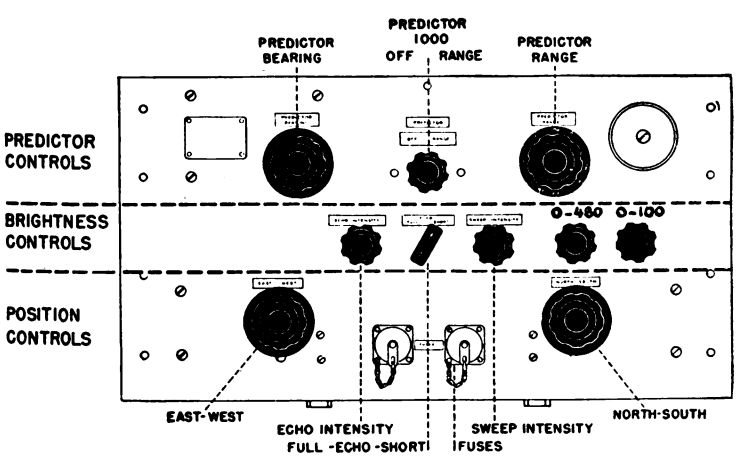

Figure 11–5.—You'll have to operate them in the dark.

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Position Controls

If you watch the POSITION CONTROLS (the lower row of controls) during an attack, you will see that they turn very slowly as the ship moves. One of these controls is marked NORTH-SOUTH, the other EAST-WEST. By turning these controls, you can immediately place the ship's spot wherever you like. There is a center mark on each dial. If you turn both knobs so that the center mark is up, the ship's spot will appear in the center of the screen. If you turn the NORTH-SOUTH control clockwise, own ship's spot will move north. If you turn it counterclockwise, it will move south. Suppose you kept moving the control counterclockwise. What would happen? The spot would move down off the south edge of the screen and then reappear at the north edge. This always happens when you turn a position control continuously.

The EAST-WEST position knob works in the same way. If you turn it clockwise, your ship's spot will move over to the right of the screen, that is, to the east. Turning it counterclockwise moves the spot to the west.

Brightness Controls

The middle row controls are the brightness controls, which control the amount of light you will see at the spot where the echo flashes on. They also control the light intensity of the sound beam trace.

The knob on the left side is the ECHO INTENSITY CONTROL. Leave this switch at the full ON position, that is, as far as you can turn it in a clockwise direction. There is an automatic gain control built into the attack plotter circuit which works together with the echo intensity control and gives all the echoes about the same brightness. With experience, you will learn how to BACK OFF the echo intensity control from the full ON position so that you can reduce noise interference and have better discrimination between weak and strong echoes.

The middle control of this group is labeled ECHO and

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has three positions, SHORT, FULL and SYNTHETIC. In the full position, the whole length of the echo will be traced in light on the screen. In the short position, only the first part of the echo is seen. In the synthetic position, the echo is generated by the range recorder.

Echoes appear as lines in the full position, and as a dot in the short position. The difference between these two is shown in figure 11–6. It is not possible to say which type of echo trace gives the best picture under all conditions. Usually the short position will give a clearer picture, but there will be times when the full position will be the better one to use. Experience in trying first one position and then the other is the best procedure to follow.

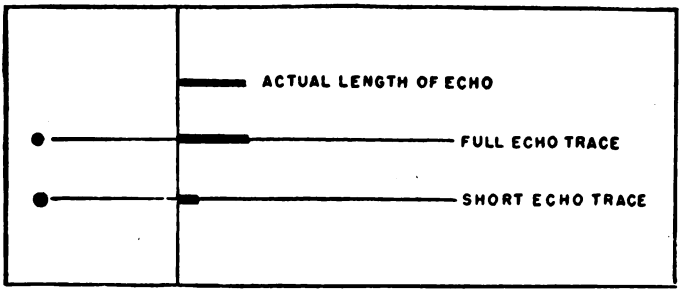

Figure 11–6.—Short is usually best at short range.

The right knob is the SWEEP INTENSITY CONTROL. It regulates the light of the sound beam trace. Set this control so that you just barely can see the trace of the sound beam as it goes across the screen.

Predictor Controls

The top row controls on the attack plotter are the predictor controls. By turning the knob at the left, called the PREDICTOR BEARING, you can train the predictor line to any true bearing desired. You can read the bearing to which you have trained from a dial mounted on top of the AP near the screen. The predictor bearing knob will turn

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freely to 20° on either side of the ship's bow, that is, from 340 R to 020 R. Outside of these limits, the knob turns with a "ratchet feel." Also, you will notice when you train through 000 R, the knob seems to pass by a notch. When you feel this, you know that the predictor knob is trained dead ahead.

To the right are two small knobs which control the PREDICTOR RANGE; in other words, by using these you can set the length of the predictor line. One knob allows you to vary the setting from zero to 480 yards in 20-yard increments. The other knob permits you to add to the range from zero to 100 yards in 20-yard increments.

The right-hand knob is labeled PREDICTOR RANGE. This controls the length of the predictor line and may be set from 190 yards to 290 yards.

The center control is a three-position switch. If you turn it to OFF, the predictor line will not appear. The middle position is marked "1000." With the switch in this position, the length of the predictor line is set at 1000 yards (4 inches). The right-hand position of this knob—the range position—allows the length of the predictor line to be governed by the predictor range knobs.

Predictor Line

By using the predictor line properly, you can determine the correct gun train for throwing weapons. Here's the way to do it. Train the predictor line to a point ahead of the submarine where you want the projectiles to hit the water. This point should be just enough ahead of the submarine to allow for the submarine's travel during flight time and sinking time of the projectiles. Practice and skill are required to do this with the accuracy needed to get hits; an accurate estimate of submarine speed is necessary, and best available target depth information must be used. Suitable templates of transparent plastic usually are prepared to assist in the operation. You can read the bearing from the indicator dial on the AP.

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When the AP is used in the attack on a submarine, this bearing becomes a course order which is transmitted to the helm electrically. The man at the wheel has a course-to-steer indicator before him which tells him the courses the AP operator needs to bring the ship into firing position. The AP is the primary means of controlling the anti-submarine attack in the majority of vessels in which it is installed, and is a valuable alternate means in others. It is well worth the most careful study.

To be a good operator, you have to understand the use of the predictor line. The first step is to make the length of the predictor line equal to the effective range (R_E). To the R_E you must add FLIGHT TIME plus DEAD TIME multiplied by OWN SHIP'S SPEED. If you were going 10 knots and firing Projector Mk 10 you would set the predictor line to the R_E PLUS 10 seconds TIMES 10 knots, or 55 yards. Fire would be ordered when the end of the predictor line was directly ahead of the submarine.

Controls in the Lower Panels

In the lower part of the AP are two panels which contain controls not used during an attack. (See fig. 11–7.) Once these controls are set properly, you should not have to change them for a long time.

There are two centering controls in the left panel, marked NORTH-SOUTH and EAST-WEST, used to calibrate the AP. They adjust the ship's spot so that it agrees with the marking on the two position controls.

The FOCUS adjustment is also in the left panel. Like the focusing adjustment on a camera, this can be set so that the light spots are sharp and clear. If it is not properly set, the lights on the screen will be blurred.

Changes in the power supply may change the scale of the screen, which is a 250-yard-per-inch scale, you will remember. The small corrections necessary to adjust this scale are made with the SWEEP LENGTH CONTROL, located in the lower left panel.

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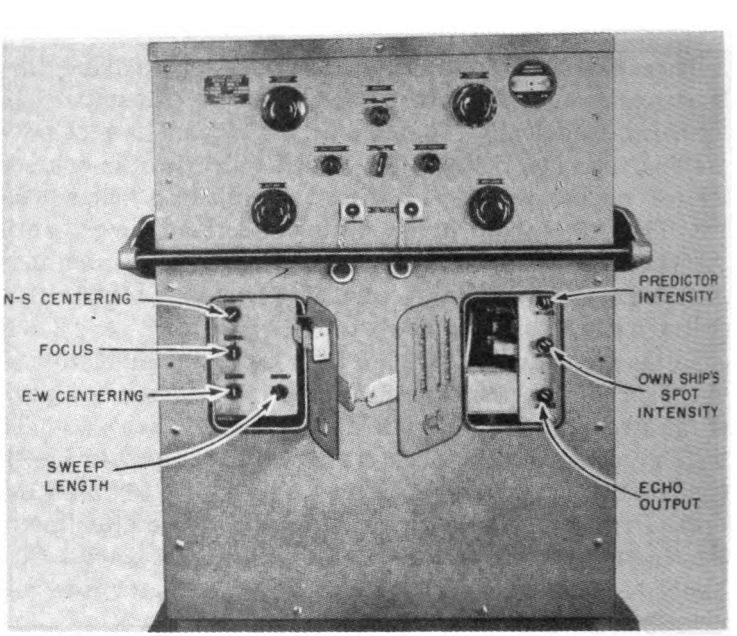

Figure 11–7.—Front view of AP, showing calibration controls.

There are three controls in the right panel. One of these controls the BRIGHTNESS of the predictor line, and another controls the INTENSITY of own ship's spot. Adjust them to any level of brightness you like best.

The third control is the ECHO OUTPUT, which limits the maximum brightness of an echo spot. It is similar to the echo intensity control. Normally the echo output control should be turned fully ON, but in a very dark UB plot there may be some advantage in turning this control down a little.

SIX MODS

The design of the Attack Plotter Mk 1 has been modified six times. The latest version is Mk 1 Mod 6, but earlier mods are still in use by the fleet. The significant modifications of the attack plotter are:

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Mod 1 was a prototype instrument to Mod 2. No PPI-scope azimuth ring was provided, and the predictor line was bidirectional.

Mod 2 effected major changes, both physically and electronically, and established a standard appearance. The unidirectional predictor line and PPI-scope azimuth ring were added.

Mod 3 provided a sonar range corrector to adjust for the varying velocities of underwater sound produced by different thermal conditions. It also added remote range and bearing transmitters to bridge and CIC for coordinated operations.

Mods 5 and 6 furnished length control and true bearing for the predictor line, provided synthetic echo, and added a synchronizing unit to permit transmission of course-to-steer orders to remote indicators.

AP AS AN ATTACK AID

You can obtain valuable information from the plot on the AP screen. Because the plot is automatic, you should be able to see the submarine's course and speed fairly

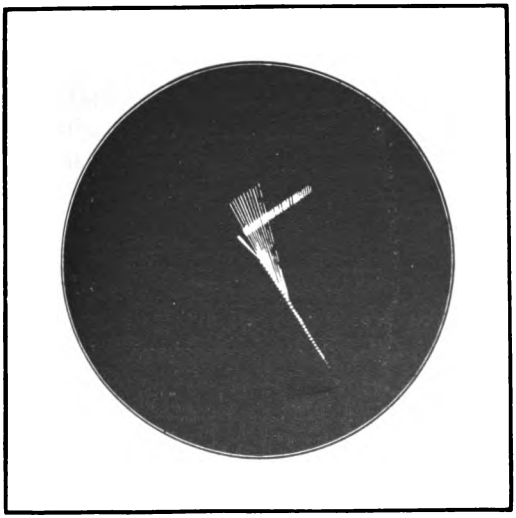

Figure 11–8.—Approaching firing time.

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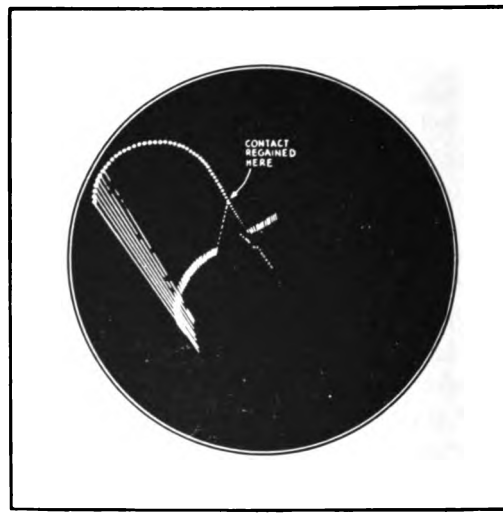

Figure 11–9.—AP operator helps sonar operator remain on target.

quickly. By using the predictor line, you can recommend an attack course, or take control of course order and firing time. You can see the approach of firing time in figure 11–8; the predictor line is about to touch the submarine's track.

When contact is lost, you can suggest search arcs. (Figure 11–9 shows the AP assisting in regaining contact.) You can also coach the console operator, helping him to stay on the submarine during an attack.

CALIBRATION CHECKS

You should know how to check the calibration of the instrument so that you will have confidence in the accuracy of the plot. To check the course plot, set the N/S positioning control at its center mark and rotate the E/W control from end mark to end mark. The spot should travel from edge to edge of the screen. Repeat this test to check the N/S motion with the E/W control centered. The accuracy

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of this calibration should be within plus or minus 60 yards (0.24 inch) at the edge of the screen.

Echo range accuracy is checked by measuring the length of the sound sweep line. This is done with the sonar equipment keying on the 1000-yard range. The ideal length is 4 inches, but a tolerance of plus or minus 40 yards (0.16 inch) at 1000 yards is acceptable. If there is no 1000-yard keying position on the sonar console, it is incorrect to set the range recorder flyback control at 1000 yards. When checking the predictor line or sound sweep at 1000 yards, use a stopwatch and set the stylus flyback to a point where 40 transmissions require exactly 50 seconds. The flyback indicator will usually be at a range between 650 and 700 yards because of the time delay between the moment the stylus strikes the flyback contacts and the recorder keys the transmitter. During this time the sound sweep continues to go out on the attack plotter screen and does not return to own ship spot until the keying impulse is received. A slight variation in the length of the sound sweep may be observed when using the range recorder. This is due to a small difference in timing when the recorder starts to key. However, the average time for 40 transmissions is satisfactory.

Predictor calibration is checked by measuring the length of the 1000-yard predictor line. This line should also be 4 inches long; a tolerance of plus or minus 30 yards (0.12 inch) in 1000 yards is acceptable.

The spot normally will travel a little farther in the north and east quadrants than it does in the south or west quadrants. Any discrepancy between east and west should be divided so that the entire plot is as close to 250 yards-to-the-inch as possible. Tolerances found necessary are small for cathode-ray tube equipment, and accuracy of the plot is not limited by these tolerances. The reason these tolerances have little effect on the accuracy is that errors in the sound sweep line and the predictor line are always in the same scale in any direction. Thus, errors in ranging with the predictor line are almost entirely canceled out.

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A final calibration check should be made to check the position of the predictor line with respect to own ship spot. Set the predictor line at right angles to the sound sweep line. Turning the predictor intensity control up bright should show the after end of the predictor line passing through own ship spot.

Over-All Calibration Checks

A quick, convenient, and altogether satisfactory method of checking calibration is described below. This type of check may be made, in part, at change of watch. The complete check may be made if a known stationary object is available for the second part of the check.

PREDICTOR AND ECHO RANGE.—This can be checked by adjusting the bearing of the predictor to coincide with the bearing of the sound sweep, i.e., the predictor is "on top" of the sound sweep. The predictor switch should be in the 1000-yard position and sonar should be keyed on the 1000-yard range. Close agreement between the length of the two lines should be obtained in all quadrants.

OWN SHIP COURSE PLOT.—The over-all accuracy of this function can be checked by pinging off a known stationary object while own ship is underway. The echo from this object should be stationary on the screen. Next, the ship is maneuvered around the object at 15 knots with constant rudder so that a circle of approximately 1500-yards diameter is scribed around this object. CIC plots this maneuver on the DRT at a scale of 200 yards per inch (closest scale to attack plotter) and you plot it on the attack plotter screen. If a perfect circle appears on the DRT but the track on the AP seems flattened or not like the DRT plot, the difference probably is caused by one of three factors:

1. Wear or looseness of the rubber cushion or play in arm. It is not necessary to tear down the equipment, but the cushions should be compressed by first loosening the setscrews of both the collar and the

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plate, and moving collar and plate to compress the cushion. If this is not done, the positioning controls will not pick up small changes from the step-by-step motors, and an inaccurate plot of the submarine track will result due to faulty movement of own ship spot. (If the same errors appear in both the DRT plot and the AP plot, the trouble probably is in the DRA and not the attack plotter.)

2. There may be play in the rotating arm of the positioning controls. This can be eliminated by placing two pieces of copper strip between the rotating arm and the porcelain mounting of the ring potentiometer.
3. Sometimes attack plotters are double keyed by the range recorder. There are two common causes for this phenomenon and both can be corrected.
    a. First, the angle at which the recorder is placed may be such that gravity causes the keying contacts to double key the recorder as well as the AP. Changing the angle of tilt of the body of the recorder will usually overcome the double keying.
    b. Second, the string connecting the stylus to the magnetic clutch may be either too tight or too loose. Changing the tension of this string will sometimes elminate double keying.

Further details of calibration and maintenance can be found in *Attack Plotter Mark 1,* OP 1101 (first revision). A copy of this publication was placed aboard with installation of your equipment.

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QUIZ

1. How large is the cathode-ray tube of the attack plotter and how much of the surface is usable?
2. What is the AP plotting scale?
3. On what relative bearing will the predictor line stay when turned on and locked in its center detent position?
4. Where is the focusing control located?
5. When is the best time to reposition the plot?
6. With the JB switch in the OWN SHIP position, what information is plotted on the screen?
7. In what position should the JB switch be kept during normal searching operations?
8. When using AP in an attack on a submarine, how is the course order transmitted to the helmsman?
9. How is own ship displayed on the AP?

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CHAPTER 12

MAINTENANCE

The effectiveness of your sonar equipment depends largely upon the care you give it. An improperly maintained search sonar, for example, can mean short ranges or no contact at all. It can offset the efforts of an excellent attack team.

The work you perform on equipment falls into two broad categories: actions you take to reduce or eliminate failure and prolong the useful life of your equipment, and actions you take when a part or component has failed and the equipment is out of service. These actions are identified by a number of terms that the *Bureau of Ships Manual* calls CATEGORIES OF MAINTENANCE. Generally, these terms refer to levels of difficulty of maintenance. Thus, operational maintenance is performed by an equipment operator who may not be a skilled technician. OPERATIONAL MAINTENANCE, according to the *Bureau of Ships Manual,* "consists normally of inspection, cleaning, servicing, preservation, lubrication, and adjustment, as required, and may also consist of minor parts replacement not requiring high technical skill or internal alignment." The next level of maintenance—TECHNICAL MAINTENANCE—requires technical skill and detailed knowledge of the equipment.

The most important source of maintenance information for sonar equipment is the Bureau of Ships instruction

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book for the particular equipment. In all maintenance work, the instruction book is your primary guide.

In a typical instruction book, sections 5 through 7 are designated operator's maintenance, preventive maintenance, and corrective maintenance. Information in these sections ranges from instructions for simple adjustments to complex circuit checks and parts replacement. The instruction book supplies information for operational and technical maintenance, even though these terms, as such, are not used in the maintenance sections of the book.

Maintenance procedures vary with the equipment. Some equipments need almost constant attention; some require only infrequent adjustment. Each instruction book provides a maintenance check chart indicating the amount of maintenance required to keep the equipment at peak performance. For convenience, equipment checks are arranged by watch, day, week, and month. The chart tells what to check, how to check it, and the safety precautions to be observed with each test.

POMSEE

An instruction book applies to all equipments of a particular type. Thus, *Instruction Book for Sonar Set QHBa* applies to all QHBa's. The Bureau of Ships, in a new approach to operational maintenance, has devised test procedures based on information in the equipment instruction books. By adding performance data for a particular piece of equipment, the result is a maintenance manual tailored to an individual sonar equipment. The new manuals, which supplement but DO NOT REPLACE the equipment instruction books, are the result of a program called POMSEE, short for "Performance, Operational, and Maintenance Standards for Electronic Equipment." POMSEE is a highly simplified approach to maintenance that permits the operator—even a striker—to perform most of the maintenance of his equipment.

As the first step, a *Performance Standards Book,* con-

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taining a series of specially developed tests and measurements for a specific equipment, was produced.

To help you understand the various tests, performance standards are grouped in the book in so-called FUNCTIONAL SECTIONS. A functional section includes all the electrical circuits and mechanical parts which act together to perform a specific function such as power, transmitting, preamplifying, receiving, etc. Tests are made when the sonar set and its critical circuits and components are operating at peak performance. Upper and lower limits or tolerances (dial readings, voltages, or currents) are given for each step. These standards tell you the level at which your equipment once performed—the level at which it will continue to perform IF YOU MAINTAIN IT PROPERLY. Correctly maintained equipment will give readings which are the same (or very near) those prescribed by the *Performance Standards Book. Performance Standards Books* are now available for most sonar equipment, including AN/SQS–10 and –11 series, AN/SQA–4, and QHBa—QHB–1.

Standards for a particular equipment are established by a sonar engineer thoroughly familiar with the equipment. He enters the data in ink in the *Performance Standards Book* and in a companion publication, *Maintenance Checkoff Book.* Standards are reestablished only after overhaul or when a field change results in new performance standards. The *Performance Standards Book* for a particular sonar set carries the model and serial numbers of that set and is permanently assigned to the equipment.

The *Maintenance Checkoff Book* contains daily, weekly, monthly, quarterly, and semiannual tests and procedures classed either as ROUTINE or TECHNICAL. Routine tests and procedures are identified in the upper right corner of each instruction page. As a beginner, you will be assigned only routine maintenance. As you gain experience, you will be responsible for technical tests and procedures. In any case, when you perform a test you must record your findings and initial the chart provided for each step.

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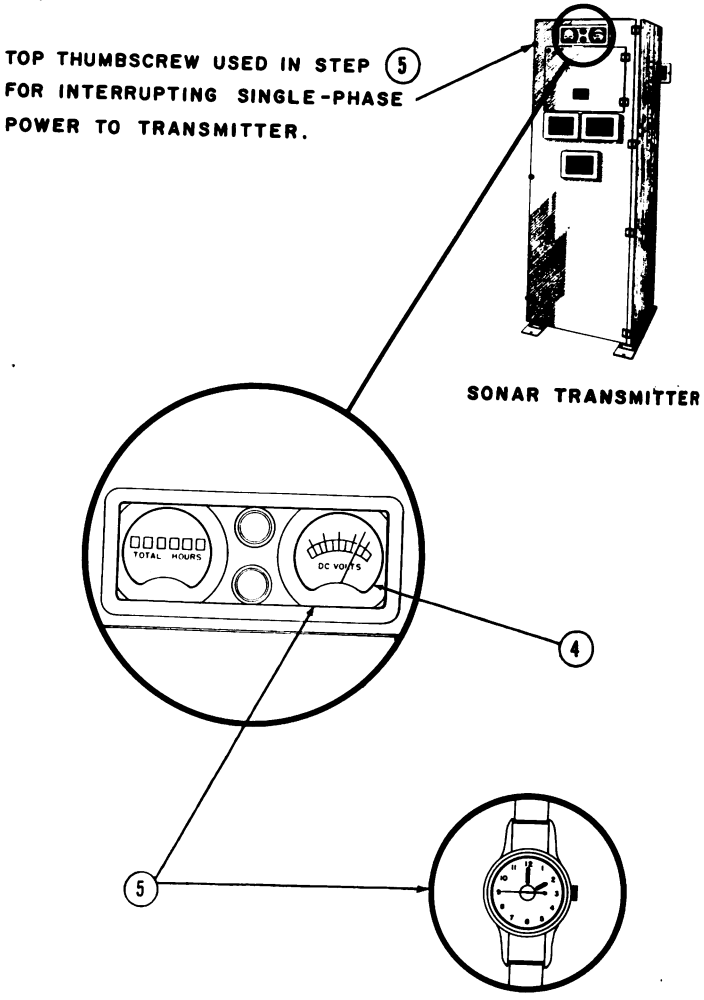

Figure 12–1.—Where you will take readings.

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A typical test for AN/SQS–10 or –11 equipment is illustrated in figures 12–1 and 12–2. The right-hand page in the *Maintenance Checkoff Book* (shown in fig. 12–2) numbers the steps, explains the actions you are required to perform, tells where to take the reading, and supplies the performance standards for that particular test. You record and initial the test reading at the bottom of the page. The left-hand page (fig. 12–1) illustrates compo-

Sonar Set in TEST OPERATION

STEP NO.	ACTION REQUIRED	PRELIMINARY ACTION	READ INDICATION ON	PERFORMANCE STANDARD
(4)	Record output of transmitter's high voltage supply. (V1001 and V1002)	None.	Panel-mounted voltmeter. (M1001)	_____ VDC (8000 ± 0)
(5)	Record in seconds, the time required for the thermal delay circuit in the transmitter to operate. (K1010 and K1003)	Interrupt the single-phase power to the transmitter by turning the top thumbscrew on the transmitter door all the way out. Wait 10 seconds. Turn top thumbscrew all the way in and simultaneously clock the time required for M1001 to read the voltage recorded in step (4), above.	Timepiece.	_____ SECS (35 to 45)

STEP NO	(4)	(5)		(4)	(5)		(4)	(5)		(4)	(5)		(4)	(5)		(4)	(5)	
Month	JAN 19__			FEB 19__			MARCH 19__			APRIL 19__			MAY 19__			JUNE 19__		
Week	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init
1																		
2																		
3																		
4																		
5																		
Month	JULY 19__			AUG 19__			SEPT 19__			OCT 19__			NOV 19__			DEC 19__		
Week	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init	VDC	SEC	Init
1																		
2																		
3																		
4																		
5																		

Figure 12–2.—Follow these steps and record the results.

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nents of the equipment, showing how and where to take readings.

The *Maintenance Checkoff Book,* like the *Performance Standards Book,* carries the model and serial numbers of your equipment. As mentioned previously, the engineer records the performance standards in the *Maintenance Checkoff Book,* where you can easily refer to them. Although maximum and minimum readings are provided, you will learn that readings can sometimes be outside accepted tolerances and still not indicate faulty equipment operation.

In time, the *Maintenance Checkoff Book* increases in value because it provides a history of equipment performance.

AZIMUTH SEARCH ROUTINE CHECKS

To acquaint you with the type of checks an operator performs to ensure his equipment is properly adjusted, the routine checks for AN/SQS–10 and –11 series equipment are explained. You can learn much from studying the procedures and the accompanying illustrations. To get the most from this section, you should have access to an AN/SQS–10, –11, or QHBa sonar set.

Transmitter

You can check operation of the transmitting circuit by observing the action of the d-c voltmeter on the transmitter chassis. The voltmeter should read somewhat less than 8000 volts. This reading should drop noticeably during transmission, recovering slowly to its original value near 8000 volts. Amount of voltage drop during transmission roughly indicates transmitted power output.

Sweep, Pulse Length, and Cursor

Sweep, pulse length, and cursor checks are performed with the equipment set up as follows:

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Switch or Control	*Position*
GYRO-ON-OFF	OFF
STABILIZATION ON-OFF	OFF
VIDEO SUM-DIFFERENCE	SUM
MANUAL ODN	0
TRANSMITTER POWER SELECTOR	NORMAL

SWEEP AND CURSOR APPEARANCE.—Place the SELECTOR switch in the 1000-yard position, set master gain control to zero, and lower control panel of the control indicator. Adjust INTENSITY control until display on cathode-ray tube screen is visible. A spiral trace will start near screen center immediately after equipment keys. This trace should expand to a point near the outer edge of the screen before the next keying pulse occurs. During this interval, the trace blanks for a short time while the cursor appears. The expanding spiral should have a circular appearance on the screen. Adjust the INTENSITY control until the display on the screen is just below threshold visibility.

Adjust the cursor bearing for brilliance by adjusting the CURSOR INTENSITY control while depressing the CURSOR HOLD switch. After this adjustment, close and secure the front control panel.

With the master gain control still set at zero, set the SIGNAL INTENSITY and INTENSITY controls of the azimuth-range indicator unit at maximum. The sweep trace on the indicator screen should disappear just below threshold visibility as the SIGNAL INTENSITY control is turned back to approximately midscale.

Advance the master gain control to produce a visible trace of moderate intensity on the control indicator screen. Reduce the brilliancy of the azimuth-range indicator screen by adjusting the SIGNAL INTENSITY control. Operating conditions will determine adjustment of SIGNAL INTENSITY, INTENSITY, and SPEAKER VOLUME. (In other words, you want a clear picture, and you want the signal to be clearly heard.) Adjust the FOCUS control for the sharpest possible trace with the INTENSITY control set for a visible trace.

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When the SELECTOR switch is in the LISTEN position, a continuous oscillating spiral sweep is produced, covering approximately the outer one-third of the screen. The double-dotted listening cursor is also continuously displayed.

SWEEP CENTERING.—With the SELECTOR switch in the 6000-yard position, reduce cursor range to zero and depress the CURSOR HOLD switch. This should produce a spot at the center of the cathode-ray screen. To prevent burning the screen, reduce cursor intensity when holding the spot for a length of time. Check sweep centering of the azimuth-range indicator the same way.

SWEEP LIMIT.—Set SELECTOR switch to 3000-yard position. Maximum usable screen radius is considered to be 2⅞ inches. This radius is the maximum range for all three scales, and the sweep trace should reach it. This limit also applies to the azimuth-range indicator.

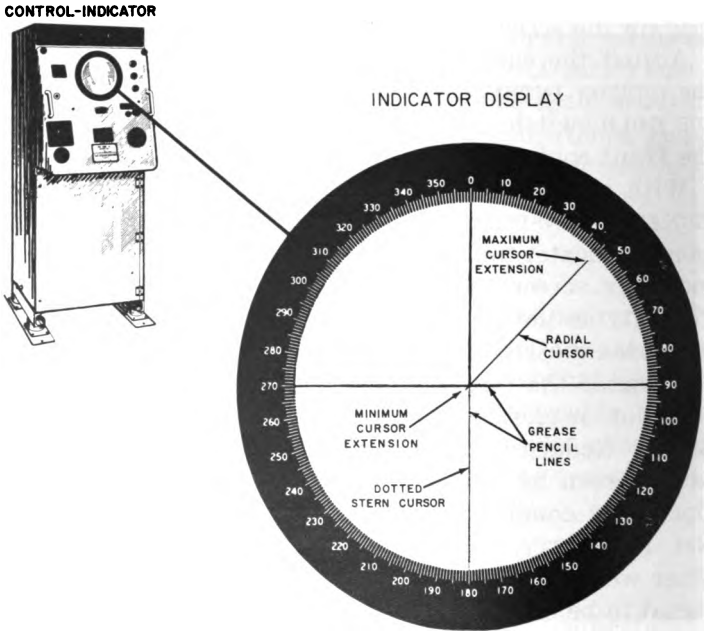

Figure 12–3.—Cursor balance.

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CURSOR BALANCE.—With the SELECTOR switch in the 6000-yard position and the CURSOR RANGE at 6000 yards, hold the cursor on the screen with the CURSOR HOLD switch. There should be no excursion (or very slight excursion) in the direction of negative range, that is, 180° from the selected bearing. (See fig. 12–3.)

CURSOR RANGE CALIBRATION.—Set SELECTOR switch to 1000-yard position and cursor range dial to 1000-yard range. If cursor range calibration is correct, cursor should extend to outer limit of spiral sweep.

SWEEP START.—With SELECTOR switch set to the 1000-yard range position and cursor range dial at exactly 100 yards, sweep start should coincide with cursor outer end. In figure 12–4, scope center is indicated by grease pencil lines from 000° to 180° and from 090° to 270°.

SWEEP RATE.—With SELECTOR switch set at 1000-yard range position, check the interval between keying pulses

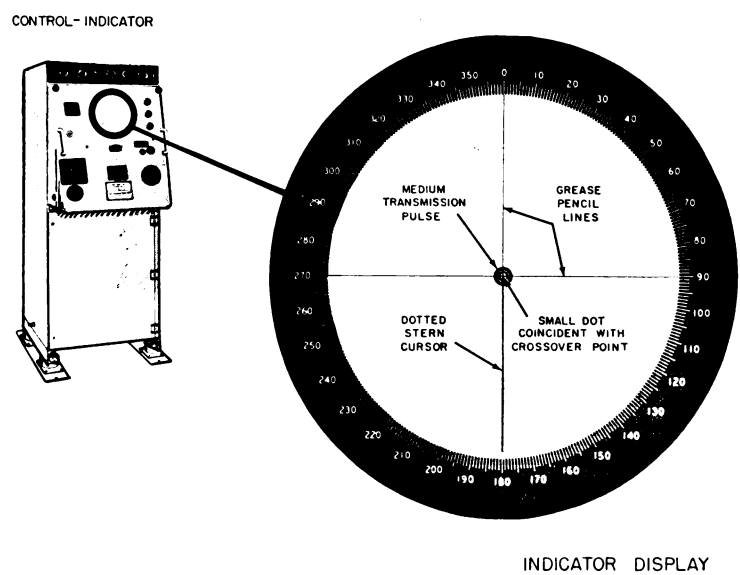

Figure 12–4.—Scope during sweep start check.

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with a reliable stopwatch. This interval should be 1.25 seconds for the 1000-yard range. After eight cycles, time elapsed should be 10 seconds. The sweep rate in the 3000-yard position is four cycles in 15 seconds, and in the 6000--yard position it is two cycles in 15 seconds.

LISTEN CURSOR.—With the SELECTOR switch in the LISTEN position, the listen cursor should appear bright enough to be easily seen. When the listening cursor is properly aligned, the bearing cursor should lie in the center of the dark area between the two dotted lines of the listen cursor. Check this as follows: Turn the SELECTOR switch to 6000-yard position, and depress CURSOR HOLD switch to get a moderately brilliant cursor image on the screen. Switch to LISTEN. The listen cursor should straddle the bearing cursor.

CURSOR TIME EXTENSION.—If a computer-recorder group is connected to the AN/SQS–10 or –11 system, and is tracking in range with the SELECTOR switch in RANGE GATED SWEEP position, the bearing cursor will remain on the cathode-ray screen until 300 yards in advance of target appearance. Check this by setting the recorder at 1500 yards and allowing range to decrease at a 20-knot range rate. Cursor should appear at flyback and remain on screen until recorder stylus is again 300 yards in advance of the target. The sweep is released from sweep start and expands at a rate to present a 600-yard sweep limit. Therefore, the target should appear approximately halfway on the sweep excursion. Any range difference from 300 yards can be estimated from the audio cursor.

STERN LINE INDICATOR.—You can verify correct operation of the stern line indicator by turning off GYRO and STABILIZATION switches and noting that the stern line indicator is at 180° relative. Check this by superimposing the audio cursor on the stern line indicator. Next, turn on GYRO switch, and note that stern line indicator moves to a bearing that is ship's head plus 180°.

PULSE LENGTH.—Set the SELECTOR switch to the 1000-yard position and the PULSE LENGTH switch to SHORT.

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Throw the pulse length test switch on the keying chassis to TEST. Operate the hand key and note that a narrow circular trace appears on the screen each time the equipment is keyed. A very slight gap should be visible between the two ends of the sweep. With the PULSE LENGTH switch at MED., note that the pattern appears as a complete circle having a wider trace than the shorter pulse.

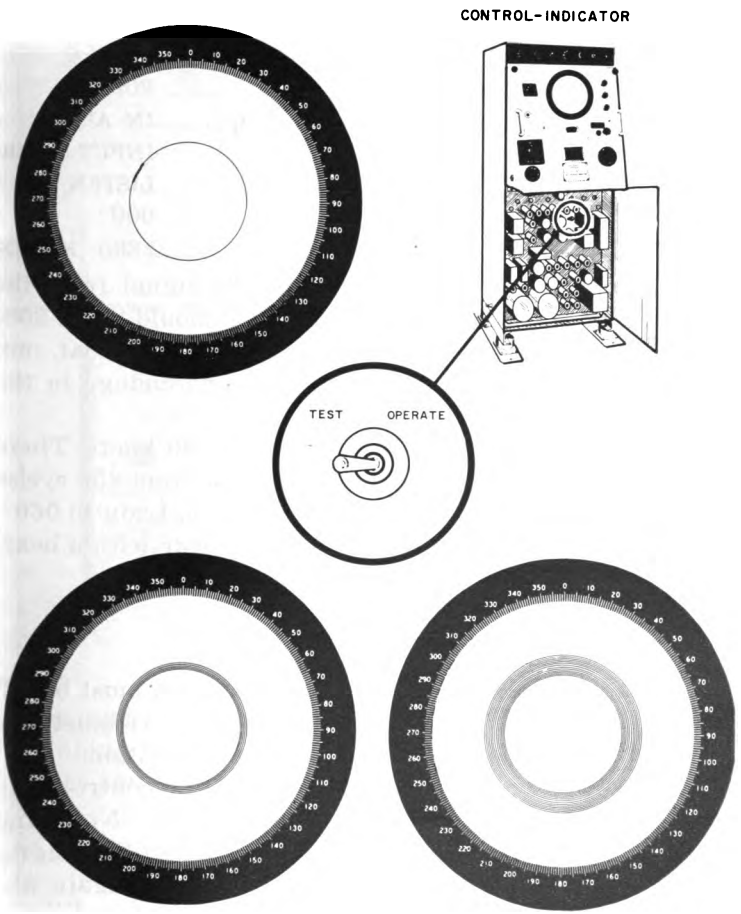

Figure 12–5.—Three pulse lengths and test switch.

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With the PULSE LENGTH switch at LONG, the circular pattern appears as a broad trace approximately two to three times as broad as the one produced by the medium pulse. Restore the pulse length test switch to OPERATE.

The three pulse lengths and location of test switch are illustrated in figure 12–5.

MANUAL ODN OPERATION.—For this test, have controls set as follows:

Control	*Position*
RECEIVER BALANCE	TEST
GAIN TEST	POS. 3
TEST PLUG	IN AUDIO INPUT JACK
SELECTOR SWITCH	LISTEN
BEARING CURSOR	000°
MANUAL ODN	ZERO KNOTS

Increase audio gain control until the signal from the loudspeaker is heard comfortably. This should be an 800-cycle note. Slew continuously around with MANUAL ODN control at zero knots; there should be no change in the 800-cycle note.

Turn the MANUAL ODN control knob to 30 knots. There should be a drop in the audio frequency (from 800 cycles to about 420 cycles). With this ODN setting, train to 060°. The note should be the same as one you hear with a bearing of 000° and a 15-knot ODN setting.

Train Control

To conduct train control tests, stabilization must be off, the attack director (if the ship is so equipped) must also be off, and the selector switch in a range position.

GYRO OFF.—Lower the front panel of the control indicator and throw GYRO OFF-ON switch to OFF. Note that GYRO OFF pilot lights on the control indicator and signal data converter are on. Raise the front panel again and set the azimuth dial to 000° with the training control knob. Bearing cursor should be at 000° on the azimuth

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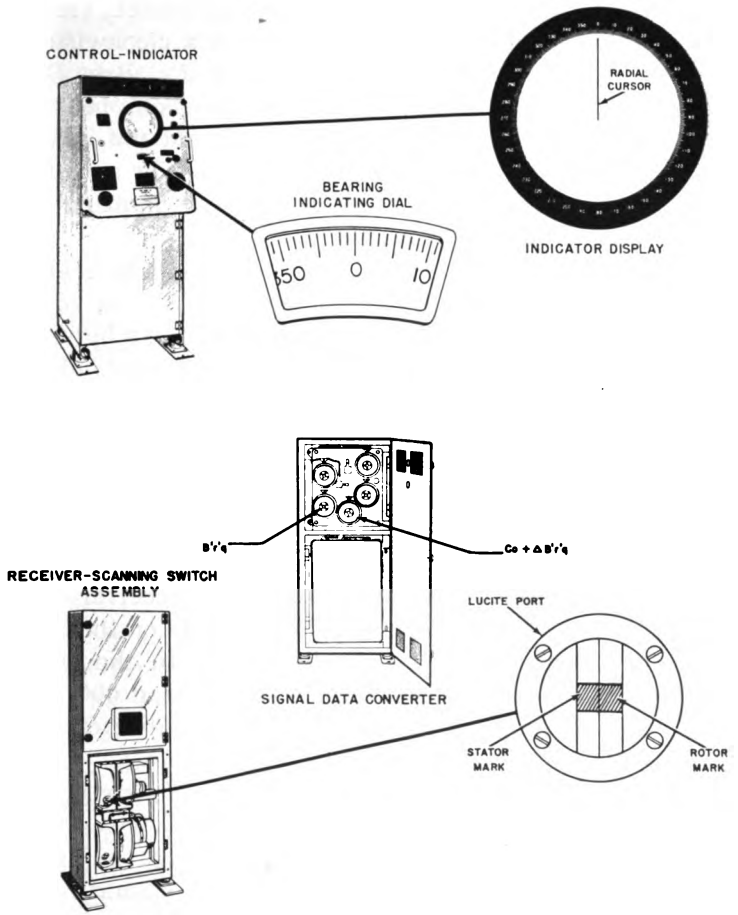

Figure 12–6.—Checking train control.

ring, and stern cursor should be at 180°. In the receiver-scanning switch assembly, check the position of the rotor in the audio scanning switch. A lucite-covered port allows you to see that rotor and stator marks are in alignment, as shown in figure 12–6. All dials on the synchro mechanism of the signal data converter should read 000°.

When you rotate the training control knob clockwise, the bearing dial and cursor should rotate in the direction

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of increasing bearing. The audio scanning switch, viewed from the stator end, should also move in a clockwise direction. In the signal data converter the *Bq, Brq, B'r'q* dials should rotate in the direction of increasing bearing, while the *Co* and *Co*+ $\triangle B'r'q$ dials should not change except for a transient response of the latter. Be sure that the audio scanning switch positions without hunting and rotates uniformly when slewing.

GYRO ON.—When ship's gyro single-phase line is energized and gyro orders are being delivered to the equipment, turn GYRO ON-OFF switch to ON. GYRO OFF lights on the control indicator and signal data converter should go off. Stabilization and the attack director should remain inoperative.

The azimuth dial and cursor indicate true bearing. Rotate the training control knob until the azimuth dial is set at ship's gyro heading. The cursor should indicate gyrocompass heading, and the stern line should be 180° away from gyrocompass heading. In the receiver-scanning switch assembly, rotor and stator marks on the audio scanning switch should be in alignment. In the signal data converter, *Brq* and *B'r'q* dials should read 000° and the *Co, Bq,* and *Co*+ $\triangle B'r'q$ dials should indicate ship's gyrocompass heading.

When you rotate the training control clockwise, the cursor and the audio scanning switch rotor (viewed from stator end) should also rotate clockwise. In the signal data converter the *Bq, Brq,* and *B'r'q* dials should rotate in the direction of increasing bearing, and the *Co* and *Co*+ $\triangle B'r'q$ dials should not change.

AN/SQR–3 AND AN/SQR–4

Sonar Receiving Sets AN/SQR–3 and –4 are azimuth search sonars of the AN/SQS–10 and –11 series adapted for use as depth-determining sonars. Except for lack of a transmitter, basic components in the system are the same. Calibration procedures and tests for these equip-

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ments are contained in *Instruction Book for Sonar Receiving Sets AN/SQR–3 and AN/SQR–4.* Once you have gained experience working with AN/SQS–10 or –11, you should have no difficulty with SQR–3 and –4.

AN/UQN–1B FATHOMETER

The operator of the AN/UQN–1B fathometer must be able to make minor adjustments to the equipment, and be prepared to replace lamps, tubes, styluses, or paper, as necessary. As operator of the equipment, you will be familiar with audio and visual responses from the equipment, and will be in a good position to sense trouble as it starts.

Before operating the fathometer, perform the five checks shown on page 350 in the operator's check chart.

Replacing Chart Paper

To replace fathometer recorder chart paper, follow the instructions below. Parts numbers are taken from the parts list in NavShips 91420, *Instruction Book for Sonar Sounding Set AN/UQN–1B.* These parts are also named and numbered in figures 12–7 and 12–8.

Open cabinet door and release thumbscrews H–204 and H–205 to allow roller O–229 to swing out. (See fig. 12–7.) TO AVOID DAMAGING FATHOMETER STYLUSES, MOVE STYLUS BELT SO THAT NEITHER STYLUS IS ON THE CHART AREA.

Wind up unused paper on take-up paper spool and remove the roll after lifting spool head O–211. Remove empty spindle on right side and install on left side of recorder. Trim end of new chart paper roll to a V-shape and install the roll on the right side. Next, pull the paper across the face of the recorder—ruled side facing out—and slip the chart up and under the depth styluses. Insert the prepared end of the paper into the long slot on the empty spindle, then take up about two turns. Return drive roller to normal position and tighten thumbscrews.

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What to check	How to check	Correction
Power supply frequency.	On 6000-fathom range, measure time for stylus travel from 0 to 6000 fathoms with accurate stopwatch. Average should be 10 seconds over five readings.	Adjust vessel's power supply frequency if not 60 cps.
Sufficient paper supply.	Paper warning light is visible through paper slots. When light is first seen, 5 feet remain (40 minutes on 600-foot range; 4 hours on 600 fathoms; 40 hours on 6000 fathoms).	Keep spare roll of chart paper on hand if supply in recorder is low. Replace paper if supply will be exhausted during anticipated period of operation.
Paper warning light operative.	Open cabinet door, release interlocks, and note whether warning lamp is lighted.	If lamp is out, turn off POWER switch and replace lamp.
Paper feed.	Paper runs smoothly at any of the three speeds and does not wrinkle.	If paper does not feed smoothly, do not adjust until you have studied section 7 of NavShips 91420.
Markings—depth.	Zero mark burns clearly starting downward from the zero line about one-eighth inch. A short tail is tolerable at the end of zero and echo marks.	See figure 12-8 for symptoms and associated remedies.

Replacing Stylus

Before you attempt to replace a recorder stylus, a word of warning: The stylus and stylus holder are assembled with a LEFT-HAND THREAD.

To replace a stylus, unscrew stylus holder nut, lift out stylus holder, and unscrew stylus. (See figure 12–7, par-

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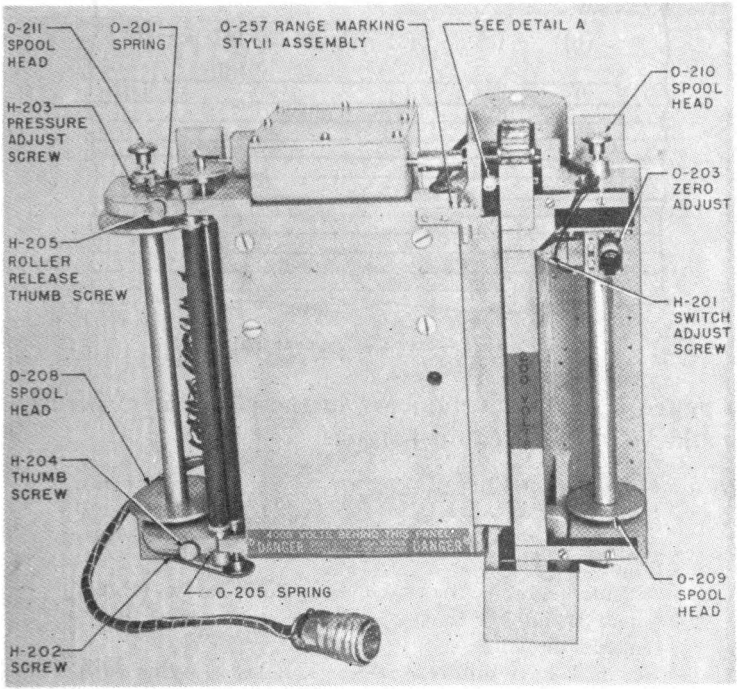

Figure 12–7.—Recorder adjustments.

ticularly the detail drawing of the stylus holder assembly.)

When you reassemble the unit, after inserting a new stylus, adjust the assembly for approximately 1/16-inch interference with the chart surface. Marks indicating correctly adjusted stylus interference setting are shown in part (f) of figure 12–8.

Before replacing stylus holder, check to make certain the rubber washer has not fallen out of the stylus holder recess. Also, rotate the stylus holder until stylus is seated before tightening stylus holder nut.

Figure 12–8 shows five conditions of incorrectly adjusted marks. These conditions and the required adjustments are listed below. Letters in the left column refer

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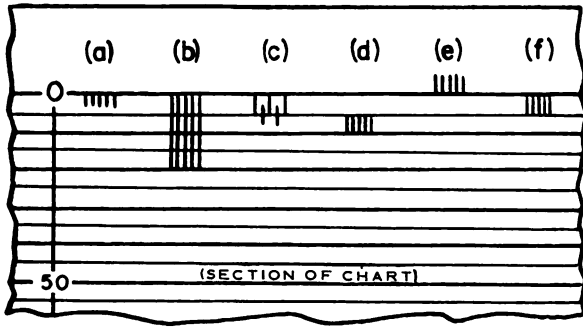

Figure 12–8.—Stylus adjustment diagram.

to figure 12–8; parts numbers in the adjustment column should be checked against figure 12–7.

Item	*Condition*	*Adjustment*
(a)	Stylus keying contacts too far from stylus bar trip, marks too short.	Turn screw (H–201) counterclockwise.
(b)	Stylus keying contacts too near stylus bar trip, marks too long.	Turn screw (H–201) clockwise.
(c)	Styluses have different interference settings, marks are staggered.	Retract stylus with greater interference.
(d)	Contacts support too low, marks too late.	Turn gear (O–203) clockwise.
(e)	Contacts support too high, marks too early.	Turn gear (O–203) counterclockwise.
(f)	Correctly adjusted marks.	None.

Lubrication

Lubrication of the recorder mechanism is a fairly simple operation, but must be done correctly and with care. Figure 12–9 illustrates seven points requiring lubrication, and specifies the amount and type of lubricant at each point. In the illustration, Q means quarterly (or 1000 hours), and A means annually (or 5000 hours). Recommended lubricants are Navy specification AN–O–11 lubricating oil and AN–G–15a, Amend.–1 lubricating grease.

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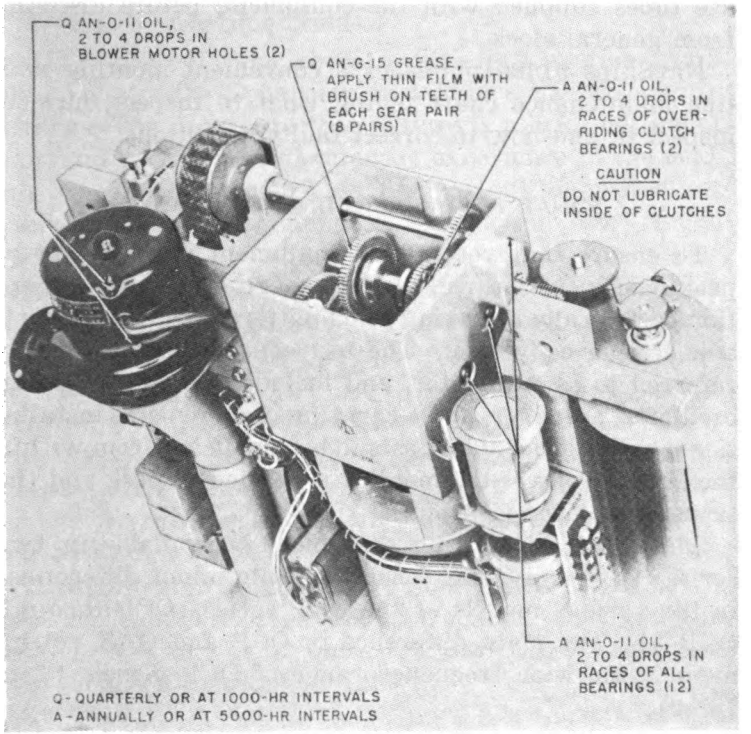

Figure 12–9.—Lubrication diagram.

Monthly Routine Maintenance

The monthly routine maintenance check for the AN/UQN–1 consists mainly of a close visual inspection of wiring, tubes, plug-in relays, resistors, and so forth. You will be inspecting for loose connections, chips and cracks, dirt, moisture, and other conditions which seem relatively unimportant but mean the difference between peak and poor performance. If left uncorrected, they ultimately lead to equipment failure. The most probable source of trouble with AN/UQN–1 equipment is electron tubes. After 500 hours of operation, all tubes should be removed from the set and tested. Defective, weak, or mechanically damaged tubes should be replaced. Always

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use tubes supplied with the equipment, before drawing from general stock.

NavShips 91420 publishes a convenient monthly routine maintenance chart telling what to inspect, how to inspect it, and how to correct faulty conditions.

SONAR PORTABLE TESTING EQUIPMENT

To ensure that your sonar equipment is operating at peak efficiency, you will test the sound output and reception periodically by taking beam patterns with sonar portable testing equipment. The test equipment is generally referred to as a monitor, and includes a transducer, an oscillator/amplifier, and a carrying case. In some installations, hull fittings allow tests to be conducted from within the ship; in others the monitor is carried on deck and the transducer lowered over the side.

Sonar portable testing equipment is available in two series: OCP and OAX. There are only minor differences in the various models of the OCP series (OCP through OCP–3). The main difference in OCP and OAX equipment is the wide frequency range of OCP models (7 to 70 kc).

Model OCP–1 is in general use in the fleet. Like other monitors, it acts as (1) a source of ultrasonic signal energy in the water to test sonar receiving circuits, and (2) a means of receiving and measuring ultrasonic signal energy, thus providing a check of transmitting circuits of the ship's sonar equipment.

The checks that this testing equipment enables you to conduct are carefully spelled out in the NavShips instruction book for the equipment. The equipment should be used for checking sonar equipment on the following occasions:

1. Whenever sonar equipment is not functioning properly;
2. At monthly intervals;
3. Immediately following drydocking;

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4. Before getting underway for extensive A/S exercises or wartime cruises.

At the present time, there is little information available to assist the Sonarman in taking sonar directivity patterns. The procedure that follows is a brief outline of steps and precautions dictated by experience in the field. This is not to be taken as a final or official procedure; check your type commander's instructions for official procedure.

For ideal conditions a ship should be anchored ALONE when a directivity pattern is performed. The water should be at least as deep as the distance from the hydrophone to the transducer.

Never attempt a pattern when nested between two or more vessels or when two or more reflecting surfaces (breakwaters, piers, etc.) are in close proximity. Standing waves (reverberations) are built up, causing the pattern to be distorted.

Never attempt a pattern in rough water. If the sea is turbulent enough to cause the hydrophone to swing in an arc over 1½ feet or if there are whitecaps, secure and wait for more favorable weather.

Azimuth Search

Many of the sections in the OCP and OAX instruction books apply to searchlight sonar. Only the chapter on operation need be modified slightly to make the monitor applicable to azimuth search sonar. Therefore, you should become thoroughly familiar with the instruction book and with searchlight techniques before attempting to operate the monitor with azimuth search sonar.

The directivity pattern performed on azimuth search sonar is in reality a "receiving" pattern made on the beam-forming elements (audio scanning switch).

Since azimuth search sonar transmits 360° in a horizontal plane, a transmission pattern, if made, would appear as a circular pattern; therefore, no transmission

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pattern is made. If desired, however, a relative transmission output can be obtained just as in searchlight operations.

The first step in using the monitor is to suspend the hydrophone in the manner prescribed in the monitor instruction book. Lower the hydrophone to about 4 feet above the depth of the transducer. If the depth of the transducer below the waterline is not known, information can be obtained from the first lieutenant or ship's plans. It is important that the hydrophone be at the correct depth so as to be on the major vertical lobe.

No cut and dried rule can be established for positioning the monitor itself; each installation varies. Experience reveals that it is usually most convenient to locate the monitor on the forecastle. Sound-powered phones should be connected between the forecastle and sonar control to enable the man at the monitor to communicate with the man at the console during operation of the monitor.

With an installation that permits testing from within the ship, the hydrophone plugs into a junction box in sonar control and the oscillator/amplifier is operated in the same space. No sound-powered communication is required.

Connect a DB meter to the audio output terminals at the console: for QHBa use terminals 1A–51 and 1A–52; for AN/SQS–10 and –11 use terminals 1A–30 and 1A–31. Set the meter to the high scale. In the following steps, references made to the DB meter pertain to this meter in the audio circuit and not to the DB meter on the front panel of the monitor.

Energizing the Equipment

Energize the sonar equipment and set the keying selector to long scale. Then energize the monitor. Set the selector switch to BEAT and tune the monitor to the frequency of the sonar transmitter following the methods described in the monitor instruction book. If no beat is

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detected at the monitor, adjust the depth of the hydrophone a few feet either up or down. Once the monitor has been set on the transmitter frequency, you are ready to make the final adjustment of the hydrophone.

Setting the Hydrophone

Be sure the console is in normal (not MCC) position. The keying selector switch should be changed to the LISTEN position. Place the monitor selector switch to SEND. On the OAX monitor, set the selector switch to SEND LOW —10 DB; this is to prevent the monitor from overloading the sonar receiver. (The line attenuator may have to be used when making an OAX directivity pattern on the bow.) For OCP-type monitors, adjust the attenuator dial to a value just strong enough to put a spoke on the console scope.

Train the cursor to 000° relative. Adjust the master gain (and audio gain on SQS only) to midposition. Switch the DB meter to lower scales until a midscale indication is present on the meter. Communicate with the forecastle by sound-powered telephone (if monitor is not located in sonar control), and have the hydrophone raised and lowered slowly until maximum deflection is obtained on the DB meter.

Caution.—If the output of the monitor is too high, causing the sonar receiver to be overloaded, it will be difficult to differentiate between major and minor lobes. After locating what is thought to be the major lobe, reduce the output of the monitor to a bare minimum. Lower scale of the DB meter if necessary to maintain a reading. Recheck the position of the hydrophone.

Secure the hydrophone line. The hydrophone will stay in this position for the remainder of the test.

Making the Pattern

Now increase the output from the monitor (change DB meter scale if necessary) until the DB meter fails to in-

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crease in deflection. At this point the receiver is overloaded. Turn the attenuator dial counterclockwise until the DB meter reading is reduced approximately 4 or 5 decibels; this is the proper level for making the pattern. Adjust the master console gain control until zero decibels is obtained on the DB meter scale being used.

On a data sheet, record the readings from the DB meter while an assistant trains the cursor clockwise from 350° relative, in 2° steps, to 010° relative. The operator at the training knob reports "Mark" as each bearing is set. At 010° continue training clockwise, in 5° steps, until 350° is again reached. Return to 000° and doublecheck the reading.

CLEANING

You can help keep your sonar gear at peak efficiency by keeping the equipment clean. An important point to remember along this line is that water and electrical gear don't mix. Don't let water drop on any part of the units, and see that cables going from one unit to another are not exposed to water.

Once a week, the inside of the units should be cleaned. Don't attempt to do this until you have checked to make sure that all the gear is dead. When you clean the inside of the unit, try to get rid of the dust that has accumulated there. The best tool for this is a dry air blower. If you don't have an air blower, use a soft brush, but be careful not to damage any of the delicate parts of the equipment.

Check for loose gear or deck plates that may rattle against the deck or bulkhead near the transducer. Lash down all loose gear. Rattling noises near the transducer will be heard through the loudspeaker, making it very difficult for you to hear an echo.

Ventilation

The sonar equipment room must always be well ventilated. All of the units of equipment located here radiate

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large amounts of heat as they operate, and unless this heat is taken away by adequate ventilation, the temperature will rise so high that it will damage the equipment. High temperature will cause the transmitter to shift frequencies radically. It will also cause certain types of train control to operate poorly. It is the Sonarman's job to see that the sonar equipment room is properly ventilated. This requires that you check all blowers used to ventilate the sonar equipment room.

ACCURATE RECORDS AND REPORTS

Complete and accurate records are an important part of antisubmarine warfare. They contribute to the material readiness of your ship and to the improvement of A/S tactics, doctrine, and equipment. A case in point is the Electronic Failure Report. This report informs BuShips of the cause and rate of electronic failures, and is used not only to maintain adequate supplies for present equipment, but also as an aid in designing future modifications and new equipment.

Directly and indirectly, complete and accurate records are necessary to keep an A/S ship at peak effectiveness. Supervision of records maintenance is an important duty of the ship's leading Sonarman. Supplying information for the records is the job of every member of the sonar gang and every member of the A/S team.

Electronic Equipment History Cards

Each ship is required to maintain a full set of Electronic Equipment History Cards for recording results of inspections and tests, and for field change entries. (See fig. 12–10.) The cards are maintained according to instructions in chapter 6 of the *BuShips Manual* and the maintenance manual for the particular equipment. They must be kept current, and available for inspection at any time. Electronic Equipment History Cards are integrated

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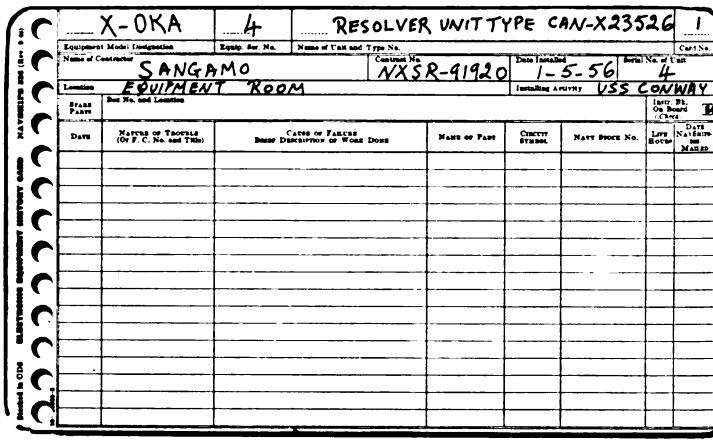
X-OKA | 4 | RESOLVER UNIT TYPE CAN-X23526 | 1

Equipment Model Designation | Equip. Ser. No. | Name of Unit and Type No. | Card No.

Name of Contractor: SANGAMO | Contract No.: NXSR-91920 | Date Installed: 1-5-56 | Serial No. of Unit: 4

Location: EQUIPMENT ROOM | Installing Activity: USS CONWAY

Spare Parts | Box No. and Location | Instr. Bk. On Board (Check)

Date	Nature of Trouble (Or F. C. No. and Title)	Cause of Failure Brief Description of Work Done	Name of Part	Circuit Symbol	Navy Stock No.	Life Hours	Date Installed and Marked

Bound in ODs ELECTRONICS EQUIPMENT HISTORY CARD NAVSHIPS 536 (Rev. 9-50)

Figure 12–10.—Electronic Equipment History Card, NavShips 536.

with the ship's current maintenance program, thereby becoming a part of the ship's material history.

Record of Field Changes

BuShips requires a record of field changes authorized for each model or type of equipment held, and a report when the change is accomplished. A separate card is used as a field change record for each equipment. As each field change is authorized, the number, title, and authority should be entered on the card. When the field change is completed, the remaining spaces of the card are filled out. Field changes should be listed numerically. Each card is filed in a binder, adjacent to the history card for the equipment to which the field change applies.

The Electronics Field Change Report is shown in figure 12–11.

Electronic Failure Report

BuShips must be informed promptly of all failures and deficiencies observed in electronic equipment for which that Bureau is responsible. The Electronic Failure Report

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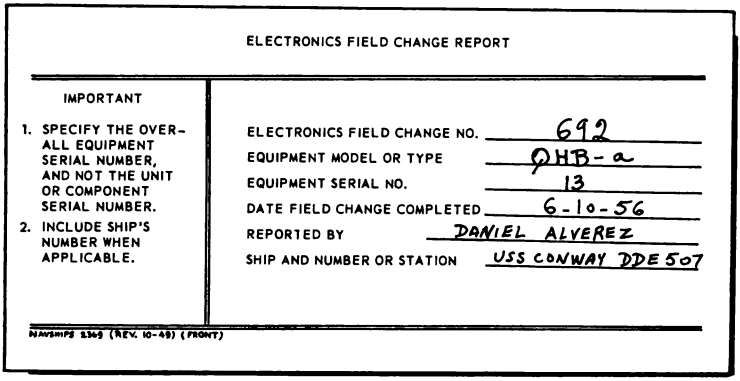

ELECTRONICS FIELD CHANGE REPORT

IMPORTANT

1. SPECIFY THE OVER-ALL EQUIPMENT SERIAL NUMBER, AND NOT THE UNIT OR COMPONENT SERIAL NUMBER.
2. INCLUDE SHIP'S NUMBER WHEN APPLICABLE.

ELECTRONICS FIELD CHANGE NO. 692
EQUIPMENT MODEL OR TYPE QHB-a
EQUIPMENT SERIAL NO. 13
DATE FIELD CHANGE COMPLETED 6-10-56
REPORTED BY DANIEL ALVEREZ
SHIP AND NUMBER OR STATION USS CONWAY DDE 507

NAVSHIPS 2369 (REV. 10-49) (FRONT)

Figure 12–11.—Electronics Field Change Report, NavShips 2369.

should be filled out promptly by the technician who either detects the failure or is in charge of the repair work.

Many failure reports have been of little value to the Bureau because they did not furnish the essential information required by the form or because the information was not complete. It is important, therefore, that the report be filled out completely and in conformance with instructions that accompany the card. A separate report should be made for each failure. When indicating the model or type of equipment, all significant nomenclature, letters, and digits should be included. Accuracy of the entry stating why the failure occurred should be verified. The importance of reporting failures and their causes, particularly circumstances existing when failures occur under actual operating conditions, cannot be overstressed.

Bear in mind that the Electronic Failure Report is not a requisition form. Replacement parts must be requisitioned separately.

Sonar Operator's Log

The Sonar Operator's Log provides a chronological record of the operation of sonar and associated equipment. No special log book is supplied. A Government

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record book, 8 inches by 14 inches, normally is used and is satisfactory for the purpose. There are no set rules for entries in the log, but following are recommended entries:

1. Names and rates of sonar personnel on watch;
2. Sonar contacts (submarines, target submarines, sonar triplane targets, buoys, surface ships, fish, kelp beds, reefs, underwater obstructions, etc.);
3. Sonar search plan and range scale;
4. Ranges obtained on various targets;
5. Sonar message from BT reading;
6. Unusual meter readings;
7. Completion of checkoff lists—for getting underway, in port, watch, daily, weekly, etc.;
8. All sonar messages sent and received by sonar equipment.

Sample entries in a Sonar Operator's Log during one watch are shown in figure 12–12.

SUPPLIES

Electronic spares are ordered and received by the supply department. When they arrive on board, Storekeepers sign spares over to appropriate departments for stowage, but maintain their own custody cards unless otherwise ordered by the commanding officer. As a Sonarman working with electronic equipment, you will profit by a knowledge of requisitioning procedures and stowage requirements of electronic spares.

Electronic equipment publications with which you should be familiar are the *Catalog of Navy Material,* Bureau of Ships Section, Part II, and *Electronic Materials Cross Reference,* NavShips 250–950. The *Catalog of Navy Material* is the basic publication for ordering Navy supplies. The *Electronic Materials Cross Reference* is a means of converting manufacturers' identification numbers or symbols to standard Navy stock numbers, if necessary.

Manufacturers' instruction books are also good sources for identification of electronic material. Parts are usually

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	TUESDAY 18 NOV. 1956 0800 – 1200 WATCH
0800	PERSONNEL ON WATCH IN SONAR CONTROL DONALD McCOY SO1 ROBERT COGAN SO2 LARRY PRICE SO3 H. R. SMITH SN (SO) R. C. MILLER FC3 CONDUCTING BEAM-TO-BEAM SEARCH ON RANGE SCALE 3,800 YARDS
0805	COMPLETED TEST OF FIRING CIRCUITS OF A/S WEAPONS AND FOUND NO FAILURES.
0830	SONAR MESSAGE WORKED OUT FROM BT OBSERVATION -- SONAR LONG 100/16MIKE. INSERTED BT INFORMATION INTO DEPTH SONAR AND RECORDER.
0930	CHECK-OFF LIST FOR SONAR EQUIPMENT COMPLETED FOR THE WATCH.
0945	OBTAINED SONAR CONTACT BEARING 085 TRUE, RANGE 2,900 YARDS. BRIDGE REPORTED BEARING FOUL -- SURFACE SHIP.
1045	QHBa EQUIPMENT INOPERATIVE
1055	QHBa EQUIPMENT OPERATING: BLOWN FUSE F-107 REPLACED.
1155	WATCH RELIEVED BY ON COMING WATCH. Donald McCoy DONALD McCOY

Figure 12–12.—Typical entries in a Sonar Operator's Log.

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listed by Navy type number, stock number, serial, or other identifying data for easy reference.

REQUESTS FOR MATERIAL

Authority for Requests

Issues for shipboard use are made by the supply department when a request from a ship's department is received. The head of each department aboard has authority to request stores for use in his department. Each request for material is signed by the department head or an officer designated by the department head.

Preparation of Requests

Requests for general stores material (GSM) are prepared on a Stub Requisition (NavSandA Form 307), shown in figure 12–13. Only one class of material is entered on each stub. When the stub requisition is presented at the GSM issue room, each request is screened to ensure that it has been filled out correctly.

Stub Record Book

When it has been determined that an issue is to be made and a stub requisition is properly prepared for the issue, the requisition is assigned the next number in the series maintained separately for each department. A stub record is kept for each department, and original entries are made in it at the time stubs are cleared in the supply office for presentation to the GSM storeroom. Notice in figure 12–14 the additional entries made on the stub by the supply office Storekeeper.

Items That Cannot Be Issued

When a stub requisition contains an item or items that ordinarily are carried but which are not in stock at the time, those items normally are canceled, and the depart-

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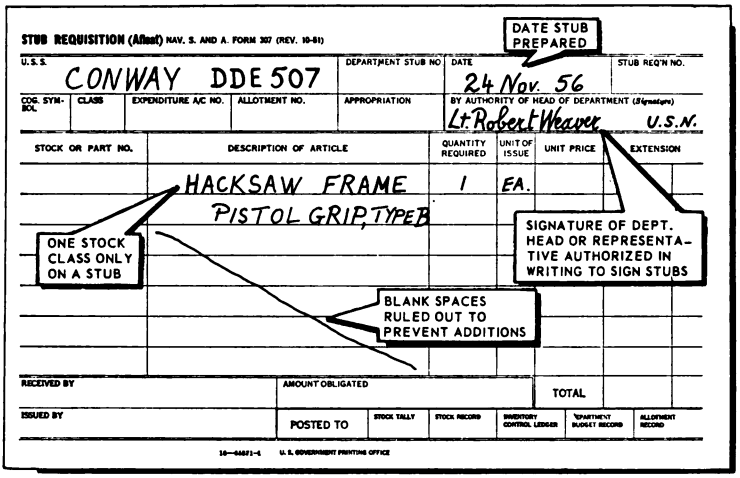

Figure 12–13.—Information entered on stub requisition.

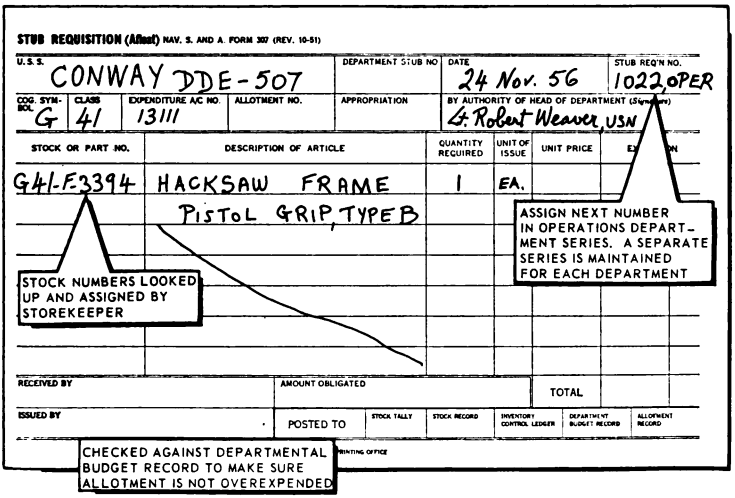

Figure 12–14.—Additional information entered on stub requisition in supply office.

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ment is requested to submit another stub after stock replenishment.

When a stub contains an item or items which cannot be supplied from stock and which ordinarily are not carried in stock, such items are ordered by the supply department. The stub is held, unnumbered, in the supply office until the material is received.

If a stub is submitted containing both items carried in stock and items that have to be ordered, the latter items are canceled. An additional stub listing these items is prepared by the department requesting the material.

Requisitioning GSM Material

The Navy uses a vast number of different items. For example, there are more than 75,000 items listed in the General Stores Section of the *Catalog of Navy Material.* If it is desired to order a certain item from the General Stores Section, it is important to have the correct stock number or parts number and nomenclature on the stub requisition to obtain the item desired. This information is obtained from the General Stores Section of the *Catalog of Navy Material,* which lists and identifies all items of general supplies carried in stock for issue to ships and stations.

The *Catalog* is grouped in 99 classes according to the general physical characteristics or types of material. For example, hand tools are listed under class 41 and general hardware under class 42. Material within one class is grouped on a logical basis with like items placed together. The *Catalog* also gives a short description of a particular item, specification, illustrations, measurement equivalents, usage data, sources of supply, requisitioning procedure, stowage notes, indexing, standard prices, and unit of issue. Aboard most ships the *Catalog* is used by a Storekeeper. However, a knowledge of the *Catalog* is helpful to Sonarmen.

Suppose you are ordering a hacksaw frame. (See fig. 12–15.) The first step is to determine what class of mate-

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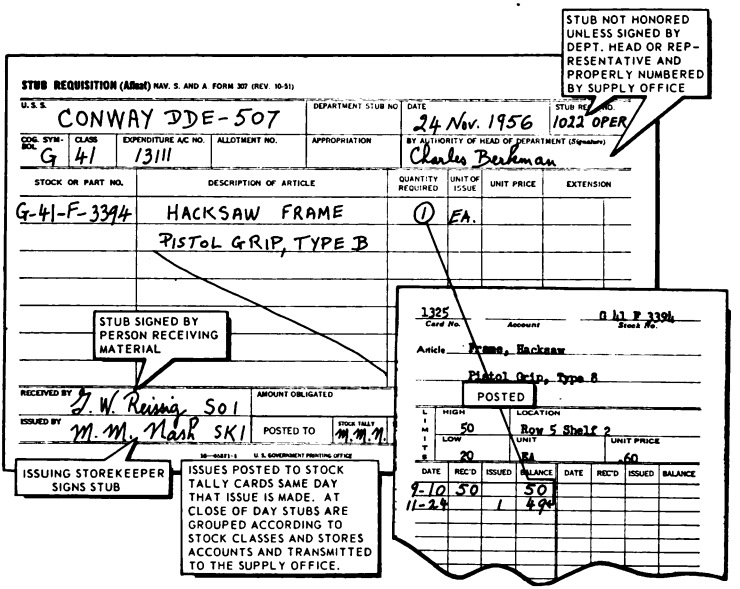

Figure 12–15.—Information entered on stub requisition and stock tally card by issue room Storekeeper.

rial contains hacksaw frames. They come under class 41. The alphabetical index at the beginning of this class lists hacksaw frames as items 1677 and 1681. The item numbers are arranged numerically and are easy to find.

Note that there are two types of hacksaw frames listed. Item 1677 has a stock number preceded by an *. This indicates that the item is obsolete and once stocks have been exhausted they will not be replenished. Should item 1681 be the desired item, the stock number and description are entered on the stub requisition. The stock number is G41–F–3394. On the stub is a square for the cognizance symbol and one for the class. This information can be obtained directly from the stock number. In the example, G indicates that this item is under the cognizance of the General Stores Supply Office; 41 indicates the class. The first letter of a stock number is the cog-

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nizance symbol; the following two or three digits, the class of the material.

Requisitioning Repair Parts

The procedure for ordering repair parts is similar to that for ordering GSM material. If the standard Navy stock number is known, it is entered on the stub requisition together with the circuit symbol and the name of the equipment. If the standard Navy stock number is not known, it is necessary to fill in not only a stub requisition but also a Request for Spare Parts (NavSandA Form 302), shown in figure 12–16.

The following information, if available, is entered on the request for spare parts:

1. Full description of electrical and physical characteristics of item;
2. Equipment name;
3. Circuit symbol of item;
4. Manufacturer's reference number;
5. Joint Army-Navy military or Army-Navy aeronautical type number;
6. Contractor's part or drawing number;
7. Navy type number;
8. Army Signal Corps stock numbers.

Stowage

Stowage of electronic spares on board destroyers and smaller ships has always been a problem, and new developments have been adding to it. To meet stowage needs, the Navy is rapidly converting all ships to bin stowage. In bin stowage, spaces are equipped with a system of drawers that provide orderly stowage and maximum protection for spares.

The selected space is divided into two areas. The first, and largest, is designated PARTS COMMON. This area holds spares used in common by several types of electronic equipment on board. This category will include fuses, resistors, certain electron tubes, etc.

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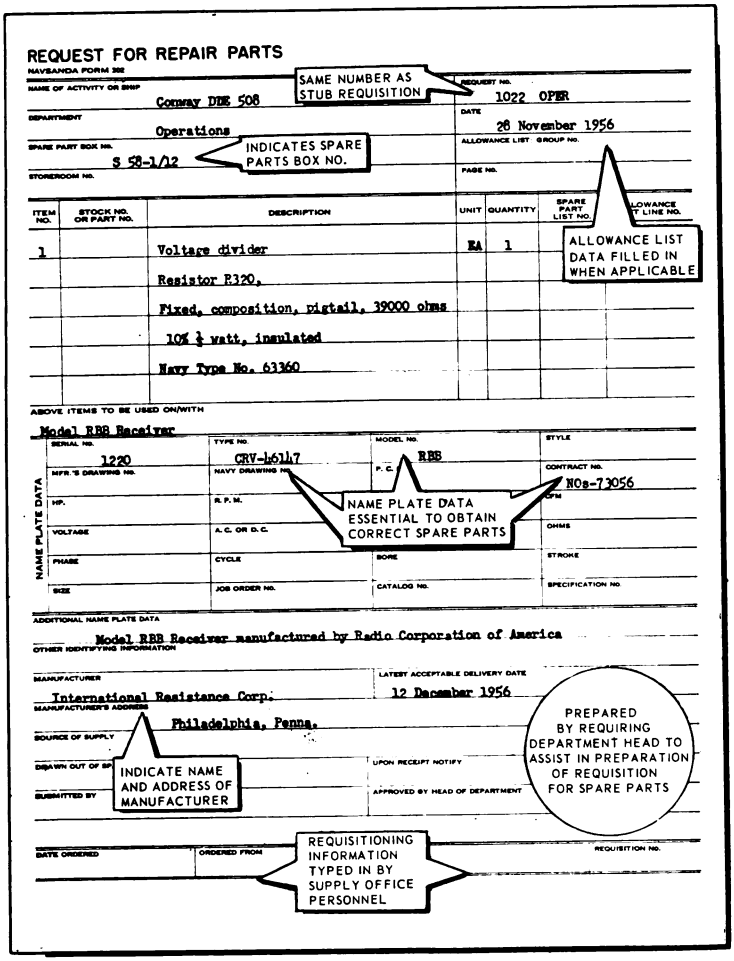

Figure 12–16.—Request for Spare Parts (NavSandA Form 302).

The second area is designated PARTS PECULIAR. This area stores parts of restricted application—those used only in sonar, or radar, or loran, etc.

Drawers in bin stowage are filled according to the standard Navy stock number of the parts. Generally, the lowest numbered parts are placed in the upper left

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Figure 12–17.—Drawers and bins for stowing spare parts.

drawer, and stowage of others follows in numerical order from top to bottom, and from left to right. A spare can be located instantly, simply by using the correct Navy stock number.

EMERGENCY DESTRUCTION

Arrangements for emergency destruction of sonar publications and equipment is made in conformance with *U. S. Navy Security Manual for Classified Matter.* The destruction bill in sonar spaces supports the ship's bill (or order) prescribing destruction of publications and equipment.

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During wartime, destructive charges are carried in brackets in the A/S fire control spaces. The charges are connected and detonated only on orders of the commanding officer. In peacetime, tools for smashing sonar and A/S fire control equipment should be available in sonar spaces. The ship's custodian will provide weighted, perforated bags for jettisoning classified publication. The destruction bill and the record of publications issued to sonar must be up to date at all times

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QUIZ

1. What book is the most important source of maintenance information for a particular piece of sonar equipment?
2. What is the full meaning of POMSEE?
3. What is the time interval between successive keying when checking sweep rate with the selector switch in the 1000-yard range position?
4. Name the three positions on the pulse length switch in AN/SQS series sonar equipment.
5. How many classes of material are entered on each stub requisition?
6. How often should parts of the AN/UQN–1B fathometer be lubricated?
7. Why is it important to take beam patterns?
8. How often should the inside of your equipment be cleaned of dust?
9. What is the title of the basic guide for destruction of classified matter?
10. When reporting electronic failures, what information, in particular, must be included?
11. Where can you find instructions for maintaining Electronic Equipment History Cards?

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CHAPTER 13

COMMUNICATIONS

There are many occasions when you will communicate with submerged submarines. In an attack run during training exercises, the usual procedure is to give the sub your approach bearing before the attack, and to report "Fire center" when weapons are launched. With the second communication, the sub releases an air slug to mark its position. Later, the A/S officer may send an underwater message requesting the sub skipper to evaluate the run.

In the past, all underwater communications were in Morse code (CW) and originated from the search sonar console. This method is still available, but is being rapidly supplanted by an underwater telephone method using Sonar Set AN/UQC–1.

AN/UQC–1

Sonar Set AN/UQC–1 provides communication, both voice and Morse code, between submarines and surface vessels. Ranges up to 12,000 yards are normal, and greater ranges are possible with good sonar conditions. In principle, the set is not too different from conventional search sonars. When the set transmits, electrical impulses are converted to mechanical vibrations by a transducer, which projects an acoustical signal through the water. When the equipment is set to receive, the transducer accepts acoustical signals from the water and converts them

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to electrical impulses. These impulses are strengthened in the receiver, and eventually drive a loudspeaker or earphones to produce the sounds that you, the operator, will hear. Although the set can be used for either voice or Morse code, it is popularly referred to as an UNDERWATER TELEPHONE. Its highest frequency is 11 kc, which means the output in the water can be heard as a high-pitched squeal by unaided ear.

The main components of the equipment are the sonar set control (operator's position), receiver-transmitter, power supply, and transducer.

Control Panel

The control panel contains a speaker and a push-to-talk microphone which plugs into a jack. To reduce the noise level in sonar spaces, a second jack is available for earphones. When you plug in the earphones, you open the speaker circuit, and sound is transferred to the earphones. The gain control (lower left in fig. 13–1) is a potentio-

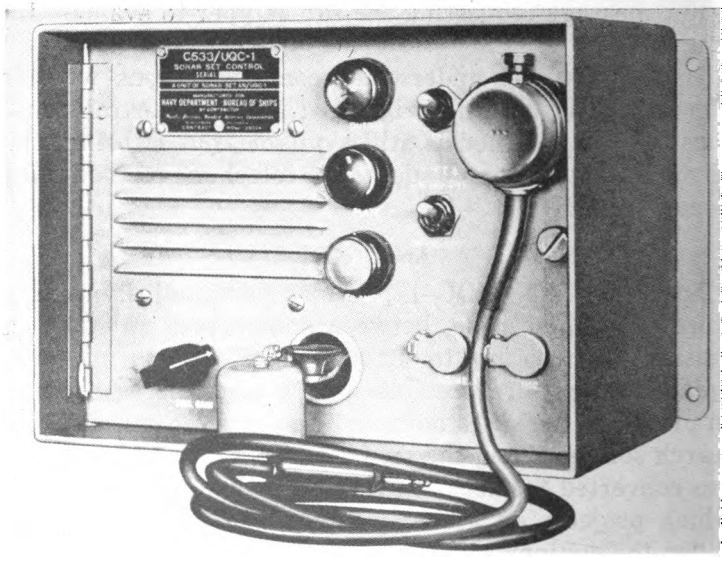

Figure 13–1.—Sonar set control.

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meter controlling the bias on the receiver amplifier tubes. It does not affect output during transmission, only the level of reception.

The remaining control on the panel is a telegraph key under a removable cover. With this key you can send CW at 8.8 kc.

Three neon lights indicate OUTPUT, PLATE VOLTAGE, and FILAMENT VOLTAGE. Their significance will be explained in the section that tells you how to operate the equipment.

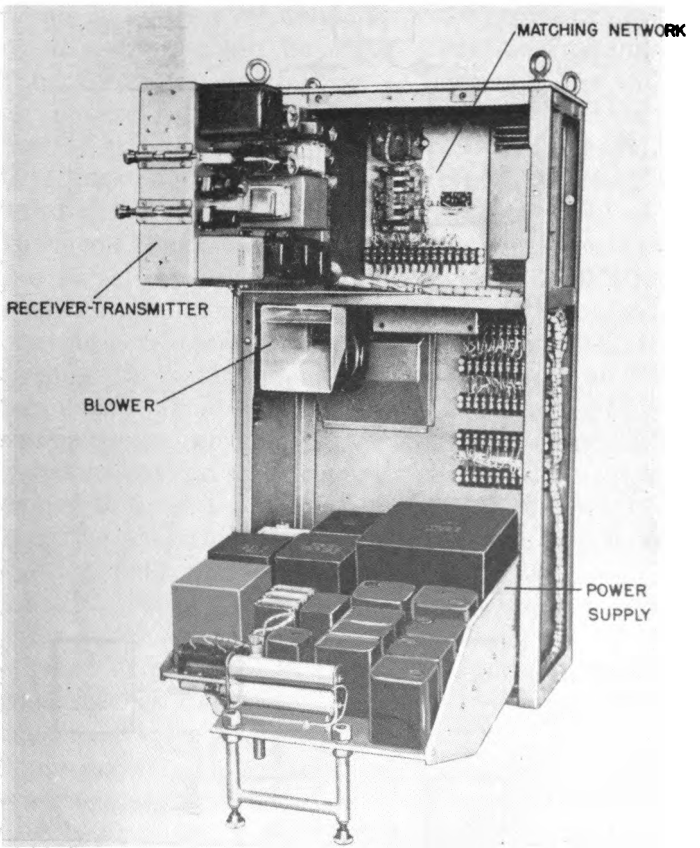

Figure 13–2.—Receiver-transmitter and power supply chassis.

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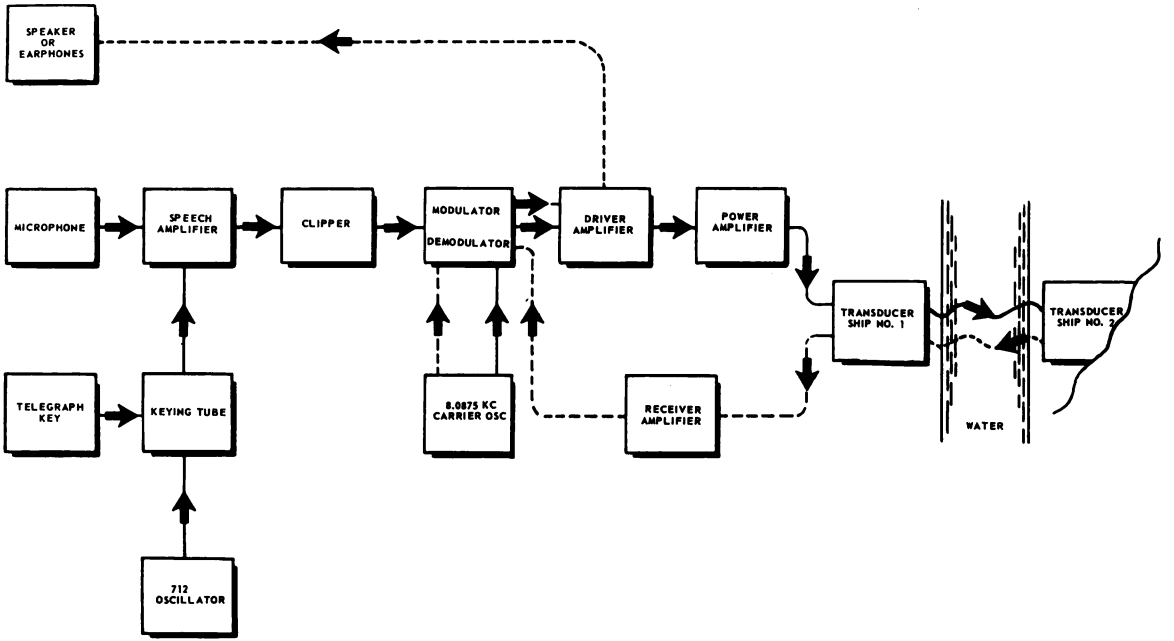

Figure 13–3.—Block diagram of outgoing and incoming signals.

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Receiver-Transmitter

Sonar Set AN/UQC–1 is a single sideband receiver-transmitter. The electronic system converts voice frequencies (250 to 3000 cycles) to the upper sideband frequencies of an 8.0875-kc carrier wave, or 8338 cycles to 11,088 cycles. The lower sideband frequencies of the carrier wave are suppressed.

The receiver-transmitter and power supply chassis, open for maintenance, is shown in figure 13–2. The block diagram in figure 13–3 will allow you to trace the processing of outgoing and incoming signals. Transmission commences at the microphone or telegraph key and the reply is received through earphones or the speaker. In figure 13–3, solid lines show transmission connections; dotted lines show reception connections. For simplicity, the power supply and its connections are omitted.

In a voice transmission, the microphone converts the audio signal into electrical impulses for amplification by the speech amplifier. Output of the speech amplifier goes to the clipper to maintain a constant output level. In the next stage the input signal is heterodyned with an 8.0875-kc oscillator signal, and the lower sideband and carrier frequencies are removed. Upper sideband frequencies are allowed to pass to the driver amplifier, where power is supplied to drive the power amplifier. The power amplifier drives the transducer, which converts the signal to acoustical energy in the water.

In CW transmission, the telegraph key controls the keying tube, which allows a signal from the 712-cycle oscillator to pass into the speech amplifier. After the signal reaches the speech amplifier it follows the same stages as a voice transmission.

Upon receiving a transmission, the transducer converts the acoustical signal from the water into an electrical signal to be amplified by the receiver amplifier. It goes next to the demodulator where it is heterodyned with an 8.0875-kc signal to separate the intelligence. The driver

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amplifier then raises the level of the demodulated wave before sending it to the speaker or earphones for reception by the operator.

Transducer

The AN/UQC–1 transducer is magnetostrictive. As you learned in the chapter on sonar equipment, magnetostrictive materials have the property of changing length when placed in a magnetic field. The active elements in the transducer which accomplish this conversion are scrolls wound from thin magnetostrictive material. (See fig. 13–4.) In the transducer the variable magnetic field is produced by axial windings through which the transmitter signal passes. This alternating current causes the

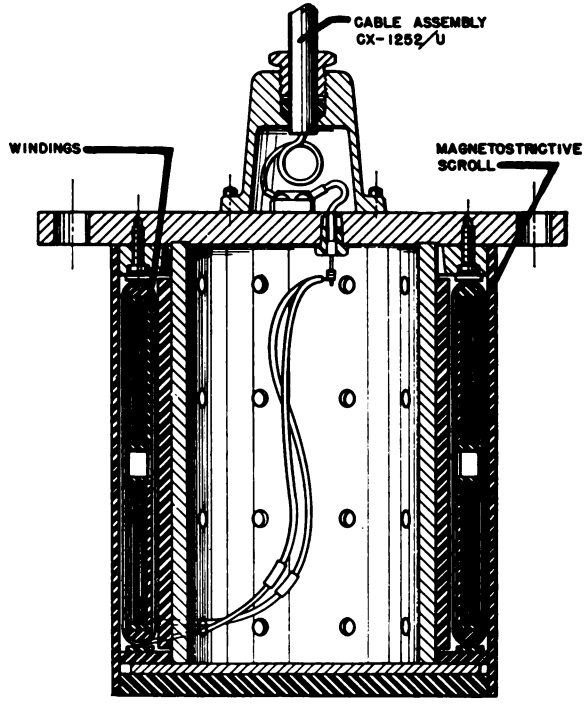

Figure 13–4.—Sonar transducer cross section.

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scrolls to expand and contract at the same frequency as the current, thus producing sound waves in water.

The reverse occurs when returning sound waves cause the scrolls to expand and contract. A voltage is induced in the windings, permitting the transducer to be used as a hydrophone when the equipment is set to receive.

OPERATING AN/UQC–1

Here are steps for operating the underwater telephone:

1. Turn OFF-ON switch to ON, noting that FILAMENT VOLTAGE glow lamp lights.
2. Wait 30 seconds until PLATE VOLTAGE INDICATOR glow lamp lights. The delay is controlled by a timer, which can be regulated. The timer dial is calibrated in tenths of a minute, and may be adjusted over a range from zero to 1 minute. Turning the dial clockwise increases time delay.
3. Put VOICE & CW RECEIVE–CW TRANSMIT switch in VOICE & CW RECEIVE position.
4. If a signal is heard, adjust gain to a comfortable level.
5. Insert microphone plug into jack.
6. Press push-to-talk switch and transmit message, holding microphone close to lips. OUTPUT INDICATOR glow lamp should flash when you talk.
7. To receive, release push-to-talk switch.
8. For CW, place VOICE & CW RECEIVE–CW TRANSMIT switch to CW TRANSMIT position. Use telegraph key. To receive CW, place switch in VOICE & CW RECEIVE.

The power delivered to the transducer is greater for CW than for speech signals. Because there is a tendency for the transducer to overheat, the equipment should not be operated on CW TRANSMIT for longer than 30 minutes at a time.

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Short Range

When necessary to operate the sonar set at very short ranges (a few hundred yards), it may not be possible to reduce the receiving gain of the system to a comfortable loudspeaker level. In this case, speak quietly, with the microphone held away from the lips. UNDER NO CONDITIONS SHOULD IT BE NECESSARY TO TALK AT MORE THAN NORMAL CONVERSATIONAL LEVEL.

OPERATOR'S MAINTENANCE

Operator's maintenance of AN/UQC–1 consists mainly of tube and fuse replacement. Figures 13–5 and 13–6 show tube and fuse locations in the power amplifier and the receiver-modulator.

If the equipment fails to operate in any switch position, chances are a tube has failed. In the RECEIVE position, tube failure may be indicated by absence of background noise when gain is turned toward maximum.

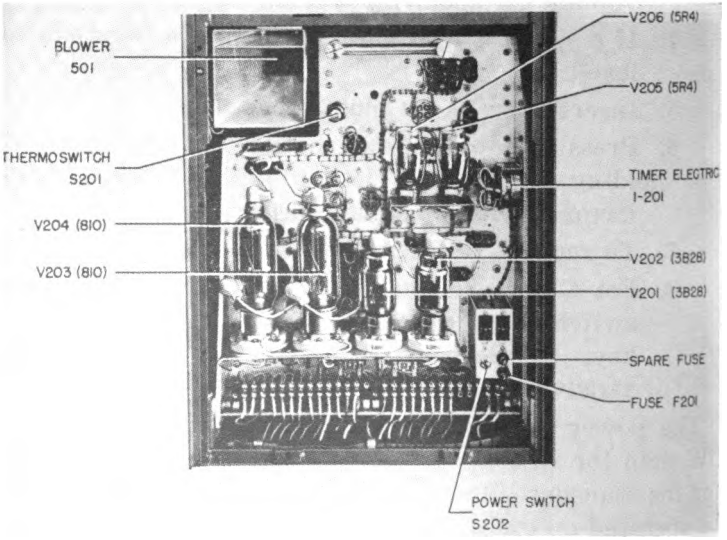

Figure 13–5.—Power amplifier tube and fuse locations.

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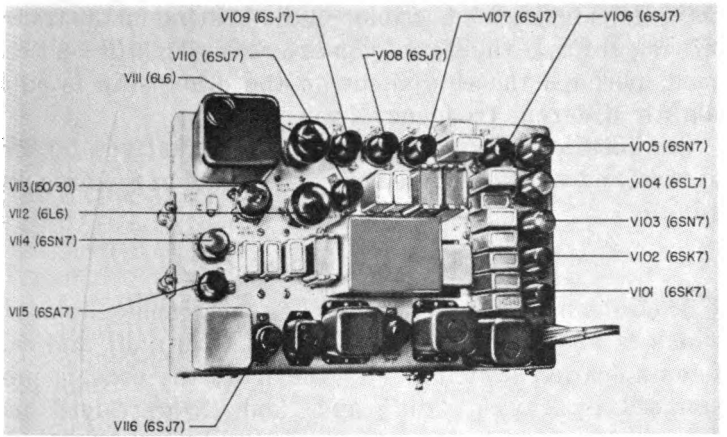

Figure 13–6.—Receiver-modulator chassis tube locations.

When tube failure is indicated, replace each tube with a new tube of the same type, or check all tubes on a standard tube tester such as Navy model OZ series.

The only fuse in the set is in series with the blower motor. With the fuse open, the blower stops operation and the set overheats. At 180°F. the thermoswitch opens and the equipment stops operation. Failure of the blower motor generally indicates an open fuse. The equipment may be operated intermittently in this condition, provided it is allowed to cool after short intervals. A spare fuse is mounted in the lower right corner of the power supply chassis for easy replacement.

HOW SONAR WORKS WITH CODE

Echo-ranging gear is good for communicating over short distances with surface vessels or submarines similarly equipped. You will find a hand key, usually located on the right side of the console, that is used to form the dits and dahs of the international Morse code.

When receiving messages by this method, the most efficient operation can be achieved by observing closely the controls of your equipment. Always keep the audiocursor

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trained, as nearly as possible, on the bearing of the transmitting ship. If the signal you are receiving still isn't too good, perhaps the equipment on the other ship is on a slightly different frequency from yours.

Qualifications for your rating require that you be able to send and receive Morse code at the rate of 8 words per minute.

INTERNATIONAL MORSE CODE

The international Morse code is a telegraphic alphabet, which is another way of saying that it is a dit and dah communication system. (By the way, the code is pronounced by saying "dit" and "dah," NOT "dot" and "dash." So forget about dots and dashes and think only in terms of dits and dahs.) The group of dits and dahs which represent each letter must be made as one unit, with a clear break between each dit and dah, and a much more distinct break between letters.

NEVER TRY TO IDENTIFY A CHARACTER BY COUNTING DITS AND DAHS. Don't let yourself get in the habit of doing so. It's a temptation at first, but you won't be able to count fast enough when the code speed picks up. Learn SOUND PATTERNS instead. To understand what this means, rap out the pattern beginning "Shave and a haircut." You recognize this from its characteristic rhythm, not from the fact it has a certain number of beats in it. You must learn code the same way. There are 36 sound patterns representing the letters and numbers. With study and drill you will learn to recognize each as fast as you now recognize "Shave and a haircut." The accent always falls on dahs, and you should pronounce each rhythmical combination with that in mind.

Go through the alphabet several times getting the sound feel of the dit and dah combinations.

Learn These Sounds

In the pronunciation guide for the sounds of the letters below, the sounds are written out as phonetically as pos-

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sible. In the middle of a group the short sound "dit" actually takes on the sound "di." The "i" is very short and the "t" is dropped.

Letter	*Pronunciation*	*Letter*	*Pronunciation*
A	di-DAH	N	DAH-dit
B	DAH-di-di-dit	O	DAH-DAH-DAH
C	DAH-di-DAH-dit	P	di-DAH-DAH-dit
D	DAH-di-dit	Q	DAH-DAH-di-DAH
E	dit	R	di-DAH-dit
F	di-di-DAH-dit	S	di-di-dit
G	DAH-DAH-dit	T	DAH
H	di-di-di-dit	U	di-di-DAH
I	di-dit	V	di-di-di-DAH
J	di-DAH-DAH-DAH	W	di-DAH-DAH
K	DAH-di-DAH	X	DAH-di-di-DAH
L	di-DAH-di-dit	Y	DAH-di-DAH-DAH
M	DAH-DAH	Z*	DAH-DAH-di-dit

Number	*Pronunciation*	*Number*	*Pronunciation*
1	di-DAH-DAH-DAH-DAH	6	DAH-di-di-di-dit
2	di-di-DAH-DAH-DAH	7	DAH-DAH-di-di-dit
3	di-di-di-DAH-DAH	8	DAH-DAH-DAH-di-dit
4	di-di-di-di-DAH	9	DAH-DAH-DAH-DAH-dit
5	di-di-di-di-dit	ø**	DAH-DAH-DAH-DAH-DAH

*Zulu may be written as Ƶ to avoid confusion with the numeral 2.
**Zero is written as ø to avoid confusion with the letter O.

Some Hints for Studying Code

If you have any trouble learning code, the following method may be helpful. Go through the three groupings of short, medium, and long sounds with their accompanying practice words. Make up words of your own if you wish to give yourself further practice. Speak the practice words in code. Say

"Tee: DAH dit dit.

Mine: DAH-DAH di-dit DAH-dit dit."

If you can speak words in code rapidly and distinctly you'll have an easy time of it when you learn to receive code because the spoken code and transmitted code sound

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very similar. PRACTICE THE FIGURES IN EVEN GROUPS: 11, 22, 33, 44, 55, 66, etc. Learn each letter by over-all sound. NEVER count the dits and dahs.

Short Sounds	*Practice Words*
E—dit	TEE, ATE, EAT, TEA, MEAT, MEET
T—DAH	MINE, TIME, MAINE, TEAM
A—di-DAH	AIM, NITE, TAME, TEA, MATE
I—di-dit	TAME, NAME, MITE, MIAMI
M—DAH-DAH	MAMA, MEAN, MAN, MAT, EMIT
N—DAH-dit	MINT, MANE, TAN, ITEM, TINT

Medium Sounds	*Practice Words*
D—DAH-di-dit	MUST, SAME, MAMA, SUIT, AUTO
G—DAH-DAH-dit	MUSS, OUST, MUSE, MUTE, ATOM
K—DAH-di-DAH	TAUT,MAST,MASS,SUET,SAM,WIND
O—DAH-DAH-DAH	SEA, TUM, SAW, OAT, SUE,SAT,WED
R—di-DAH-dit	SUM, MUD, IOU, USE, SEAM, WOOD, DARK
S—di-di-dit	GEORGE, DOWN, KIND, SORT, DOOR MASK
U—di-di-DAH	WORK, GROW, WOMAN, EDGE, GAGE
W—di-DAH-DAH	WIGS, WORM, WAGER, WAKE, KEG

Long Sounds	*Practice Words*
B—DAH-di-di-dit	VAT, VET, VIM, HAM, SIX, SAY
C—DAH-di-DAH-dit	HAS, HAT, EVE, CUT, CAM, VEST
F—di-di-DAH-dit	HEAT, HAVE, MUCH, THAT, EACH
H—di-di-di-dit	COAT, ACHE, SAVE, HUSH, ACME
J—di-DAH-DAH-DAH	CUTE, CHARLIE, FIVE
L—di-DAH-di-dit	HOW, JIMMY, LIKE, PAPA, QUICK

Long Sounds	*Practice Words*
P—di-DAH-DAH-dit	QUILL, VICTORY, XRAY, YOUNG
Q—DAH-DAH-di-DAH	ZERO, BUZZ, GARGLE, FIZZLE
V—di-di-di-DAH	LYNX, OXYGEN, WAX, QUAY
X—DAH-di-di-DAH	JERKY, WHIP, QUEBEC
Y—DAH-di-DAH-DAH	
Z—DAH-DAH-di-dit	

Figure Sounds

1—di—DAH-DAH-DAH-DAH	6—DAH—di-di-di-dit
2—di—di-DAH-DAH-DAH	7—DAH—DAH-di-di-dit
3—di—di-di-DAH-DAH	8—DAH—DAH-DAH-di-dit
4—di—di-di-di-DAH	9—DAH—DAH-DAH-DAH-dit
5—di—di-di-di-dit	ø—DAH—DAH-DAH-DAH-DAH

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THE ONLY WAY TO LEARN CODE IS TO PRACTICE, PRACTICE, PRACTICE. THE VALUE OF PRACTICE CANNOT BE OVEREMPHASIZED.

Receiving

If you have carried out the recommendations made up to this point, you are ready to receive code transmitted to you on a hand key. The ship or station to which you are attached will have practice hand keys which you can use.

Find a Radioman who will key code groups to you to help you in your training. The sound produced by keying an oscillator resembles the sound of code from the sonar gear. As you progress, you can gain speed by shortening the space BETWEEN characters.

Notice in figure 13–7 that the characters themselves may be keyed at a faster speed, but that the longer intervals between characters and words materially decrease the beginner's over-all speed.

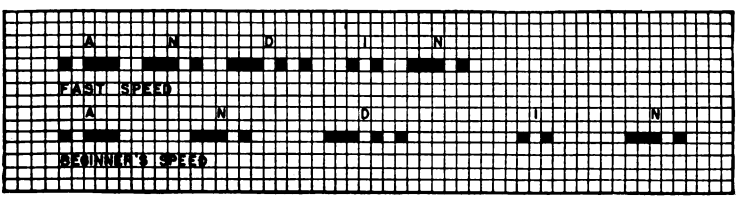

Figure 13–7.—Correct keying of code characters.

After learning the sound of each character at this rate of speed, it is not difficult to reduce the time BETWEEN characters and to copy code at a much faster speed.

As you advance in rating, you will be required to increase your transmission and reception speeds. It will be easier if you learn the fundamentals well. BE A COMPETENT OPERATOR. Make every transmission and reception an accurate one. Do not seek speed before accuracy. Here are some code practice exercises that will help you.

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CODE PRACTICE

1. E E E T T T A A A N N N I I I S S S H H H
M M M O O O E E E T T T A A A N N N I I I
S S S H H H M M M O O O E E E T T T I I I
M M M A A A N N N S S S O O O H H H E E E
T T T E E E T T T I I I M M M I I I M M M
A A A N N N A A A N N N S S S O O O S S S

2. U U U V V V D D D B B B K K K C C C W W W
J J J P P P U U U V V V D D D B B B K K K
C C C W W W J J J P P P W W W J J J P P P
U U U V V V K K K C C C B B B D D D U U U
D D D V V V B B B P P P J J J C C C K K K
W W W D D D B B B V V V U U U W W W J J J

3. R R R L L L F F F G G G Z Z Z X X X Y Y Y
Q Q Q R R R L L L F F F G G G Z Z Z X X X
Y Y Y Q Q Q G G G Z Z Z F F F L L L R R R
Y Y Y Q Q Q R R R X X X Z Z Z R R R F F F
L L L Q Q Q Y Y Y G G G Q Q Q Y Y Y R R R

4. 1 1 1 2 2 2 3 3 3 4 4 4 5 5 5 6 6 6 7 7 7
8 8 8 9 9 9 Ø Ø Ø 1 1 1 2 2 2 3 3 3 4 4 4
5 5 5 6 6 6 7 7 7 8 8 8 9 9 9 Ø Ø Ø 1 1 1
2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 Ø Ø 1 1 2
2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 Ø Ø 1 2 3 4
5 6 7 8 9 Ø 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6

5. V U I Y Q Z C X G R S L K J P Q X Z R I F
C V B W F K D S H Q Z A L K F B V R S T U
O T M E G Y Z X V E G N I W S L H M U A E
V U A E W Q G H V C I X Z L N R Y U K V U

6. E 8 Y 7 B 6 X 1 W Ø Z 2 A 3 C 5 S 4 I 2 F
U 1 F 5 D 8 Q 4 T 6 U 9 Q 2 E Ø S 5 U 1 Y
G 2 J 4 S 3 E 5 T 7 Z 8 K 6 M 9 R 1 A 2 R
S 7 W 8 E 9 R 2 A 3 Z 3 X 6 U 8 B 7 C 6 T

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CODE PRACTICE

7. MI AN SY NL TY CE DO PS CX ZW QA PK LN HU WC VN
BM ZS CD QA IU SD LM UH GY TR DC VT AR YU FD SA
IG WQ XT ZI NY OT ED BM LP YU GH BY RE DF LS WQ
XS ZI TY BG NH JV KL MD MI AN SY NO TY CE DO PS

8. EF TS 16 29 83 ZJ 45 Ø7 WR ND KW IC UX 91 Ø2 IB
LO FG 84 63 XW AC TM SU 5Ø 72 XR RJ ZM 43 65 VH
97 LM 12 46 7Ø FC FE EY 34 56 27 FT FY JU IT 98
76 75 52 DE WE QT 13 36 57 KF RI YT 19 93 35 41
FK YU 96 Ø1 MC AR TH 19 25 3Ø UR BO UL 32 Ø5 21

9. NDT EGH RTS LYB FCC ZEX PIH CWE LKJ QIE NUG CVT EPL
SZW QAU SH
GBT VRT GIK GYO DCM XSD ZAU YER DLN URG HNB VDX ZWS
QTA GHI PT
MBY PLK RDC ESX IUP PKJ NYH GHT DFR VED SWN VBT XFZ
RDA SEN FU
GBC YRF DSE WNJ GVA SWQ QIX ZOT MEH GKD BGV CFI ATA
RUR SAC LT
NVR DAB GLM INY EGB LKO MWD SKZ QLD YGB NDT EGH RRS
FLM FCC ME

10. O V L H M Y B L U R X O H I Z O V I C T
F I N X X C X S H T Y V I Q N T U B M L
A B L B E J L N C Y Z B Z W C N J N D Z
U T L Z K L A B D E F Z V N U W K F R E

11. JICOY TXSTY 38Ø95 RDIHA JXTDZ
OXPDW ZPZSY RSPHD 897Ø6 CUSPI
RNBRJ 65289 ZONIG FYEQU ARQNV
RNLPT KAKOZ 8784Ø BVGAN WKOQT
SRQMT UJVWN 45872 YXBCX AFKOZ
OGLCT NIHGP 12349 ATUSK SLEWQ

12. O L M X M V N H U W Q R N V U T K U X F
C D E H L Y H E D I P A Z Q W I Z Y S K
Q I Q A W M N W Z I H Z C A K D B T G W
W N L I P W B U O X A D X F R J I Q C A

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13. ZMJXI URYNC 9347Ø PQAZM DEGVM
NCBVG HUGHY 13267 PHRAN QUECC
1289Ø MCNDH EUIRY WQAZX IRSVZ
MCURI 72439 OYTRW PIQAW CNJWO
OWQAJ OISKM 1Ø7Ø6 DGFHG KSBOU

14. U T H A V N C B R F D S E D C D C X V D
R W Q I M N J F S T R O T N B L U J H K
N I O Q J U Y R G B N S V C X T R J T U
B C D V C G F H 5 7 8 1 J H V X H G J D

Sending

Your ability to send will depend mainly upon two things: First, you must KNOW THE CORRECT SOUND OF THE CHARACTER you are attempting to transmit; second, you must KNOW THE PROPER METHOD FOR KEYING. Practicing the code out loud, as well as having received it by oscillator, has given you a good knowledge of code sound. The proper method for keying is your next concern.

Probably the first key you will contact is the UNSHIELDED TELEGRAPH KEY normally used on practice oscillators, on shipboard, and on station circuits. The key must be properly adjusted before you can transmit CLEARCUT characters. Use the screws on the key to obtain good control. The gap between the contacts should be just large enough to allow you to key easily.

The side screws should be centered and adjusted by tightening to prevent the keying bar from moving sideways. The spring screw should place just enough tension on the key so that the key is easily depressed yet springs upward at the end of each dit or dah.

You should learn from the beginning the correct way to grasp the key.

The following is the proper procedure for becoming a proficient operator. Follow the instructions as listed.

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Do not hold the key tightly, but let your fingers rest lightly on the key knob. Your thumb rests against the side, your forefinger rests on top of the key, with your third finger bent and relaxed lightly with remaining two fingers.

YOUR ABILITY TO TRANSMIT DEPENDS TO A LARGE EXTENT ON ACQUIRING THE PROPER MOVEMENTS OF YOUR WRIST AND HAND WHILE OPERATING THE KEY. To close the key, your wrist moves upward and your hand rocks downward toward your fingertips. To open the key, these two movements are reversed—your wrist comes down and your hand rocks back.

Conditions of the water have a bearing on the signals you transmit. There will be times when you can transmit rapidly and your signals will be clearly audible. At other times you may have to go very slowly, or your dits and dahs cannot be distinguished by the receiving operator.

UNDERWATER TELEGRAPH PROCEDURE

Knowledge of Morse code isn't enough to enable you to send a sound telegraph message. You must also have a working knowledge of simple radiotelegraph procedure, which is the basis for sound procedure. You won't need to master all the details because sonar communications are kept to a bare minimum, and those sent are of brief, plain style. If you learn the procedure given here you will be able to handle any underwater message you are ever likely to encounter.

PROSIGNS

Procedure signs, or PROSIGNS, are single characters, or combinations of characters, that have a prearranged meaning. They convey in short standard form certain frequently sent orders, instructions, requests, and the like, relating to communications. An overscore means that the prosign is sent as one character—that is, without the normal pause between letters.

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13. ZMJXI URYNC 9347Ø PQAZM DEGVM
NCBVG HUGHY 13267 PHRAN QUECC
1289Ø MCNDH EUIRY WQAZX IRSVZ
MCURI 72439 OYTRW PIQAW CNJWO
OWQAJ OISKM 1Ø7Ø6 DGFHG KSBOU

14. U T H A V N C B R F D S E D C D C X V D
R W Q I M N J F S T R O T N B L U J H K
N I O Q J U Y R G B N S V C X T R J T U
B C D V C G F H 5 7 8 1 J H V X H G J D

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Conditions of the water have a bearing on the signals you transmit. There will be times when you can transmit rapidly and your signals will be clearly audible. At other times you may have to go very slowly, or your dits and dahs cannot be distinguished by the receiving operator.

UNDERWATER TELEGRAPH PROCEDURE

Knowledge of Morse code isn't enough to enable you to send a sound telegraph message. You must also have a working knowledge of simple radiotelegraph procedure, which is the basis for sound procedure. You won't need to master all the details because sonar communications are kept to a bare minimum, and those sent are of brief, plain style. If you learn the procedure given here you will be able to handle any underwater message you are ever likely to encounter.

PROSIGNS

Procedure signs, or PROSIGNS, are single characters, or combinations of characters, that have a prearranged meaning. They convey in short standard form certain frequently sent orders, instructions, requests, and the like, relating to communications. An overscore means that the prosign is sent as one character—that is, without the normal pause between letters.

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Prosign	*Meaning*	*Remarks*
AA	All after.	Used to identify portions of a transmission when requesting a repetition.
AB	All before.	
WA	Word after.	
WB	Word before.	
K	Go ahead and transmit.	Every transmission ends with one or the other of these prosigns.
$\overline{AR}$	End of transmission; no reply expected or desired.	
$\overline{AS}$	I must pause for a few seconds.	
$\overline{AS}$ $\overline{AR}$	I must pause longer than a few seconds.	
$\overline{BT}$	Long break.	Separates text of message from heading and ending.
II	Separative sign.	Used for all other separations in messages. Write it as a short dash.
DE	From.	
EEEEEEEE	I just made an error.	Corrected version is sent immediately.
$\overline{IMI}$	Repeat.	
R	I have received all of your last transmission.	

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SHIP'S CALL SIGNS

Every radio station—ship, shore, or aircraft—must have an identifying sign. This sign—or CALL SIGN—is a combination of letters, or numbers and letters, used in the exchange of communications among radio stations. These same call signs are used also in sonar communications. Call signs of ships of the United States Navy always begin with N and have four letters.

EXAMPLES:

USS *Conway* (DDE 507) ..... NFBD
USS *Seawolf* (SSN 575) ..... NBWY

PARTS OF A MESSAGE

Morse code underwater messages are written and sent in three parts: the call, the text, and the ending.

Call

The call is a transmission directed to the station with which you wish to communicate, requesting that station to answer. Begin the transmission with the call sign of the station you are calling. Follow this with the prosign DE (from), then the call sign of your own ship and finally the prosign K. In the following example USS *Cony*, a DDE (call sign NILX), calls the submarine *Catfish* (call sign NJRV):

Call: NJRV DE NILX K
Reply: NILX DE NJRV K

Cony now repeats the call without the prosign K and proceeds with the text of the message.

After communication is established, further calling and answering incident to transmission of a message is usually handled by ABBREVIATED calls. The abbreviated call omits the call sign of the station called. However, if there is any possibility of confusion, a full call should be used.

Full Call ..... NJRV DE NILX
Abbreviated call ..... DE NILX

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Text

The call is followed by the TEXT, which is the main part of the message. It is the basic idea or information that the originator (station with information to send) desires to communicate to the addressee (station receiving the message). It is the reason for existence of all other parts of the message. It may be sent in plain language or it may be sent encoded. To save transmission time, Sonarmen use a special 3-letter code with meanings that cover most of the information exchanged in underwater communications. The code is contained in FXP 1. Some examples of this type of code are shown below. These are not actual meanings; they are simply examples which demonstrate typical coded information with which you will operate.

Code group	*Meaning*
BBB	Come to base course.
MMM	I am preparing to surface.
KKK	Release water slug.

You can see that the use of coded groups for texts of underwater messages greatly shortens the time required to exchange information. Even so, you will handle many underwater messages with plain language texts. You can be sure, however, that these texts will be kept as brief as possible.

The heading and text of a message are separated by $\overline{\text{BT}}$. In the same manner, the text and ending are also separated by $\overline{\text{BT}}$.

Ending

The ENDING marks the conclusion of the message. In underwater sound communication the ending usually consists only of the prosign K or $\overline{\text{AR}}$, depending upon whether a response is or is not required.

USE OF PROSIGNS

Receipts

No message is considered delivered until the receiving operator gives a receipt for it. The prosign R means "I

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have received all of your last transmission." In the example following, NTPK sends a message to NOLT, and NOLT sends back a receipt.

Message: NOLT DE NTPK $\overline{BT}$ MMM $\overline{BT}$ K
Receipt: NTPK DE NOLT R $\overline{AR}$

Correcting an Error

If you make an error in sending, make a series of eight or more E's. This is the error sign. It is sent immediately after the error. Go back to the last correctly sent word, group, or prosign, repeat it, and continue with the correct version.

EXAMPLE:

NTMU DE NUBP $\overline{BT}$ CEASE EK EEEEEEEE
CEASE EXERCISE $\overline{BT}$ K

This procedure applies regardless of where the error occurs—in the call, text, or ending. When followed by the prosign $\overline{AR}$, the error sign means "This entire transmission is in error; disregard it."

EXAMPLE:

NTMU DE NUBP $\overline{BT}$ EEEEEEEE $\overline{AR}$

Waits

The prosign $\overline{AS}$ means "I must pause for a few seconds." It may be sent at any time. If it is followed by the ending sign $\overline{AR}$, it indicates a pause of more than a few seconds duration.

EXAMPLE: During transmission of a message the sending operator desires a delay.

. . .AT POINT NOVEMBER $\overline{AS}$..Momentary delay.
. . .AT POINT NOVEMBER $\overline{AS}$ $\overline{AR}$....Longer delay.

Repetitions

The prosign $\overline{IMI}$ means "Repeat." Used alone, $\overline{IMI}$ means "Repeat all of your last transmission." Followed by identification data, it means "Repeat the indicated por-

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tion of your transmission." Remember that you can combine IMI with prosigns meaning "All after," "All before," "Word after," and "Word before."

EXAMPLES OF REPETITION REQUESTS:

DE NTMU IMI K.....Repeat all of your last transmission.

DE NTMU IMI WA TORPEDO K..Repeat word after "torpedo."

DE NTMU IMI AA BT.....Repeat all after BT (the first BT is always meant).

Replies to above requests:

DE NOLT NTMU DE NOLT BT TORPEDO SIGHTED BT K

DE NOLT WA TORPEDO SIGHTED K

DE NTMU AA BT-TORPEDO SIGHTED BT K

The prosign IMI is also used by senders. In the text of a plain language message, it means "I am going to repeat the difficult portion just transmitted." Between the first and second transmissions of a message being sent twice, it means "I am going to repeat this message."

UNDERWATER TELEPHONE PROCEDURE

Underwater telephone procedure closely parallels underwater telegraph procedure. Construction of messages is the same, and so are principles of calling, receipting, correcting errors, waiting, and obtaining repetitions. You will notice two important differences: (1) instead of 4-letter N call signs, telephone communications uses ships' radiotelephone call signs, which are more easily spoken and understood; and (2) instead of prosigns, you use PROWORDS. Here are the proword equivalents of the prosigns you have learned.

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Prosign	*Proword*
AA	ALL AFTER
AB	ALL BEFORE
WA	WORD AFTER
WB	WORD BEFORE
K	OVER
$\overline{AR}$	OUT
$\overline{AS}$	WAIT
$\overline{AS}$ $\overline{AR}$	WAIT OUT
$\overline{BT}$	BREAK
DE	FROM
EEEEEEEE	CORRECTION
EEEEEEEE $\overline{AR}$	DISREGARD THIS TRANSMISSION
$\overline{IMI}$	SAY AGAIN
R	ROGER

Calling and Answering

Here is an example of a call from a tame submarine (call sign WEASEL) to an A/S ship (call sign LONGSHOT). Dashes shown are not actually sent, but show pauses the operator makes so that his transmission can be more easily understood. Prowords are italicized.

LONGSHOT—*THIS IS* WEASEL—*OVER*
WEASEL—*THIS IS* LONGSHOT—*OVER*

With communication established, WEASEL sends his message:

LONGSHOT—*THIS IS* WEASEL—*BREAK*—AM READY—AT REQUIRED DEPTH—SPEED—AND COURSE—*BREAK*—*OVER*

LONGSHOT gives a receipt, using an abbreviated call:

THIS IS LONGSHOT—*ROGER*—*OUT*

Correcting an Error

If you make an error in transmission, send the proword CORRECTION at once. Go back to the last correctly sent word or proword, repeat it, and continue with the correct version.

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AB	ALL BEFORE
WA	WORD AFTER
WB	WORD BEFORE
K	OVER
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$\overline{AS}$	WAIT
$\overline{AS}$ $\overline{AR}$	WAIT OUT
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LONGSHOT gives a receipt, using an abbreviated call:

THIS IS LONGSHOT—*ROGER*—*OUT*

Correcting an Error

If you make an error in transmission, send the proword CORRECTION at once. Go back to the last correctly sent word or proword, repeat it, and continue with the correct version.

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EXAMPLE:

WEASEL—*THIS IS* LONGSHOT—*BREAK*—ALL HERE — *CORRECTION* — ALL CLEAR SURFACE—*BREAK*—*OVER*

Waits

When an operator finds it necessary to delay momentarily, the proword is WAIT; if the delay is for longer than a few moments, the transmission is WAIT—OUT. When communication is resumed a new call is made.

Repetitions

The request for a repetition is SAY AGAIN, NOT "Repeat." Used alone, SAY AGAIN means "Repeat all of your last transmission." Followed by identification data, it means "Repeat the indicated portion of your transmission." The answer to SAY AGAIN is I SAY AGAIN, followed by the repetition requested.

EXAMPLE: WEASEL asks LONGSHOT to repeat all of his last transmission, and LONGSHOT complies.

THIS IS WEASEL—*SAY AGAIN*—*OVER*

THIS IS LONGSHOT—*I SAY AGAIN*—WEASEL—*THIS IS* LONGSHOT—*BREAK*—CHANGE BASE COURSE TO ZERO NINER ZERO—MAINTAIN PRESENT DEPTH AND SPEED—REPORT WHEN READY—BREAK—OVER

If WEASEL had missed only the word NINER, he would have framed his request as follows:

THIS IS WEASEL—*SAY AGAIN*—*WORD AFTER* TO ZERO—*OVER*

He would not ask for word after zero because there are two zeros in the message. When WEASEL has the message complete, he sends a receipt.

Belaying a Transmission

To cancel a message in progress, cease sending immediately and transmit the proword DISREGARD THIS TRANSMISSION.

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EXAMPLE: LONGSHOT's operator begins a message and is then ordered to belay it.

WEASEL—*THIS IS* LONGSHOT—TAKE STATION—*DISREGARD THIS TRANSMISSION—OUT*

INTERNAL A/S COMMUNICATIONS

Reliable exchange of information among primary A/S stations is essential for successful antisubmarine operations.

Several internal communication systems are available:

1. Sound-powered telephone circuits;
2. MC circuits.
3. Voice tubes;
4. Light signals;
5. Warning signals;
6. Automatic transmission systems.

Search attack information and orders are relayed, whenever possible, by automatic transmissions.

It is recommended that you review the sound-powered phone sections in *The Bluejacket's Manual,* and in *Seaman,* NAVPERS 10120–B. Internal A/S communications are covered in more detail in *Sonarman 3 and 2,* Vol. 2, NAVPERS 10139–A.

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QUIZ

1. Sonar Set AN/UQC–1 provides CW and voice communication up to about _____ yards.
2. Name the four main components of the Sonar Set AN/UQC-1.
3. Why should you not operate the sonar set on CW TRANSMIT for more than 30 minutes at a time?
4. A dit is what fraction the length of a dah?
5. What does an overscore mean above a prosign?
6. What prosign separates the text of a sonar message from call and ending?
7. How can you identify CW call signs of ships of the United States Navy?
8. All CW sound messages end with one of two prosigns. Name the two and tell when each is used.
9. What are the underwater telephone equivalents of the prosigns in question 8?
10. How can a sender cancel an underwater telephone message he is transmitting?
11. In receiving Morse code, why should you never count the dits and dahs?

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CHAPTER 14

HARBOR DEFENSE

A PLACE OF PROTECTION

A harbor is a haven for ships. It's a place where vessels come to load and unload, take on stores and fuel, and be protected from the elements. Besides protection from strong winds and high seas, a harbor must also offer protection from the enemy in time of war. Once a ship makes port, protecting her from the enemy is largely the responsibility or HARBOR DEFENSE, a unit of the local defense forces.

Your studies this far have emphasized shipboard sonar. Nearly everything you have learned about behavior of sound in water, submarine characteristics, doppler, and so forth, applies as well to harbor defense. In a harbor, as well as in the open sea, the long-range patrol-type submarine is a formidable enemy, and sonar is an important method of detecting that enemy. But there are other methods of detection: magnetic loops, hydrophones, and sonobuoys. Sonarmen assigned to harbor defense usually serve with the UNDERWATER DETECTION (UD) component, operating all types of underwater detection equipment.

Sneak Craft

In attempting to penetrate a harbor, the enemy often employs special assault units, which harbor defense men

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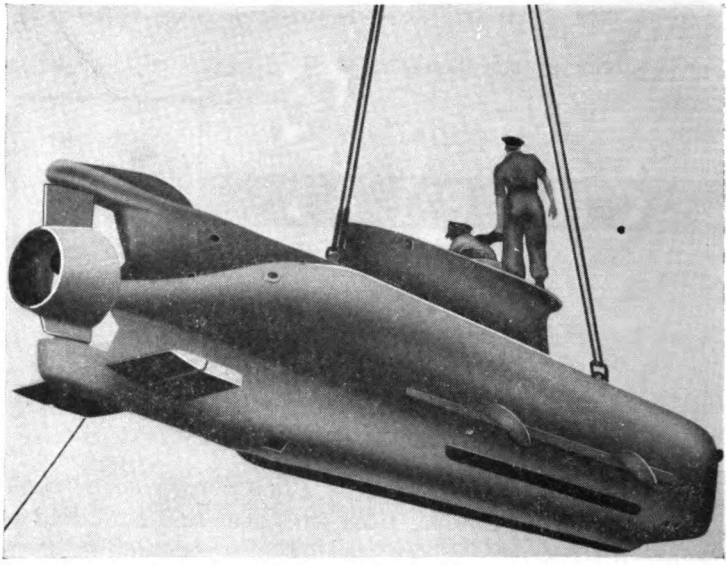

Figure 14–1.—A type of two-man midget submarine.

call "sneak" craft. These include midget submarines (similar to the one shown in fig. 14–1), one- and two-man torpedoes with detachable warheads, suicide swimmers, and fast surface boats with explosive-filled bows. Another sneak craft is the "friendly" fishing vessel which comes in at nightfall, planting a string of mines in the channel.

Don't get the idea that sneak craft are freaks. They are deadly weapons, and they sent thousands of tons of shipping to the bottom in World War II. An explosive charge attached to the keel can break a merchantman's back; it can put a carrier in drydock for months. In World War II, a single Italian assault flotilla, equipped with two-man torpedoes and other sneak craft, sank more than a quarter of a million tons of shipping, including two battleships, a cruiser, and a destroyer. In all instances, the ships were at anchor inside booms and nets, and in harbors under constant watch by patrol craft.

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HARBOR DEFENSE UNIT

The harbor defense unit protects port facilities and shipping from attack by undersea and sneak craft of all types. Included is protection from mines and from disguised attack by any type of vessel. The harbor defense commander is responsible to commander base defenses, or the local defense force commander for the effectiveness of his unit. Figure 14–2 is a block diagram of the harbor command relationship. Of importance to you are the blocks with heavy borders, which indicate the components of harbor defense to which you may be assigned. Most Sonarmen will serve in underwater detection stations, but you may also assist in the harbor entrance control post (HECP), or be a member of the mining group, controlling harbor minefields. Depending on the size and importance of the harbor, there may be several underwater detection stations, or there may be a single control point, with all components centered about HECP.

Harbor Entrance Control Post

The harbor entrance control post is the center of the entire harbor defense system. It is a military guard post

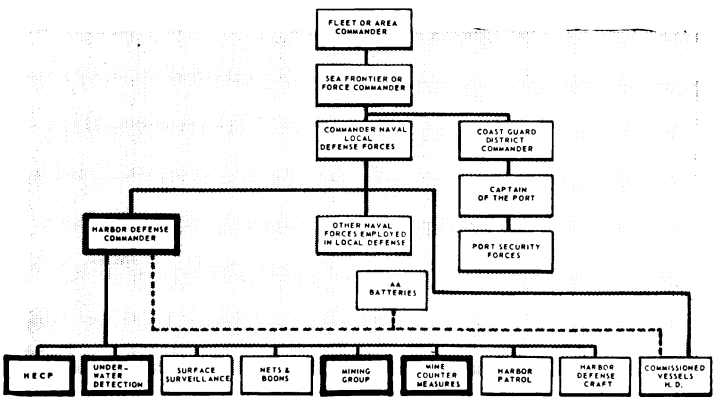

Figure 14–2.—Harbor command relationship.

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whose function is to prevent entrance of unfriendly vessels to the harbor. HECP is somewhat like a shipboard CIC, and is the agency through which the harbor defense commander controls his unit. It collects, displays, and evaluates information upon which the harbor defense commander's decisions are based. For example, a submarine attempts to invade the harbor over a magnetic indicator loop. Underwater detection sounds the warning, and immediately notifies HECP. From its plot of all surface ships in the area, HECP begins evaluating the contact. The location and movement of every surface vessel near the harbor entrance is checked. If radar indicates no surface target in the area, the contact is assumed to be submerged, until positive evidence to the contrary is obtained. HECP immediately alerts the harbor entrance patrol, mine stations, and other combat forces, and may even order additional patrol craft to search for and attack the invader. UD continues to develop the contact, providing information, through HECP, until the patrols obtain their own contacts or until the intruder is sunk or driven off.

The watch officer in HECP (in charge in the absence of the harbor defense commander) has duties that compare with those of a shipboard OOD. When an enemy is detected in the harbor, he takes immediate action to nullify the attack or danger. He then advises the harbor defense commander and the local defense force commander of the situation.

The control post is always located where ships approaching or leaving the harbor can be seen easily. Its most prominent feature is a visual signaling tower from which incoming vessels are challenged, usually by flashing light. Every ship is required to identify herself before entering. With the exception of signaling and lookout stations, the remainder of the post will be located underground.

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Underwater Detection

Underwater detection's place in the underwater attack picture is similar to that of shipboard sonar control. Information on underwater targets comes into the harbor defense net via UD equipment. An attack can be stopped only if you, the underwater detection operator, relay accurate information for the control post to act upon. Remember, the entire harbor defense organization goes into action when you report your contact.

UD Equipment

Most vessels, and all submarines, are built of steel, and thus have magnetic properties. To take advantage of this magnetism, special MAGNETIC INDICATOR LOOPS have been designed to record any distortion of the earth's magnetic field caused by the presence of an iron body over it. Loops are laid on the ocean bottom. The magnetic field of a vessel passing over the loops is recorded on chart paper as a "signature," and the recorder mechanism in the station sounds an alarm. A sub drifting in with engines dead can be detected by loops. See figure 14–3.

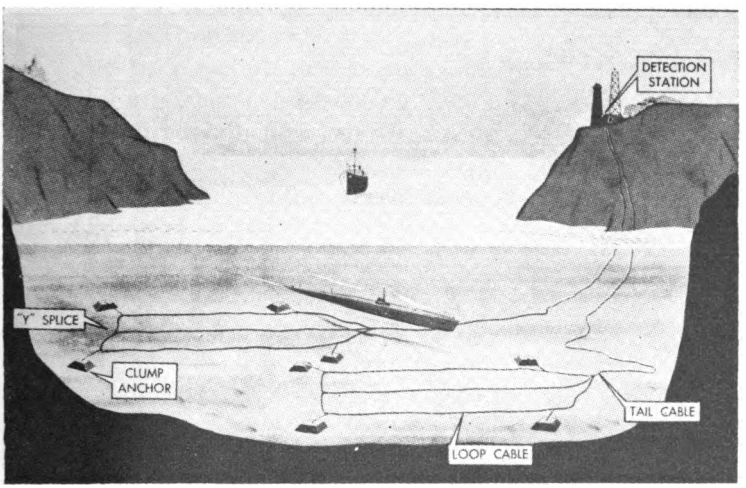

Figure 14–3.—Magnetic indicator loop.

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Loops are extremely sensitive and they have a way of never getting tired, no matter how long and dull the watch. For these reasons, loops are generally placed to seaward where they can sound the first warning.

After the loops comes the SONIC LINE. Two types of equipment stand guard here: cable-connected hydrophones, and radio sonobuoys. Both are sensitive listening devices, which pick up sounds generated by a submarine's propulsion machinery and transmit them to receivers in the underwater detection station. The hydrophones transmit information by submarine cable. Sonobuoys perform the same listening function, but their information is transmitted ashore by radio instead of cable. The sonobuoys are used when the water is too deep for hydrophones, or when there isn't time to lay submarine cable. See figures 14–4 and 14–5.

The first warning, then, comes from the loops. They tell you that the outer defenses have been penetrated. Next come the hydrophones, which tell you WHERE the penetration was made. A sharp operator listening to sounds from

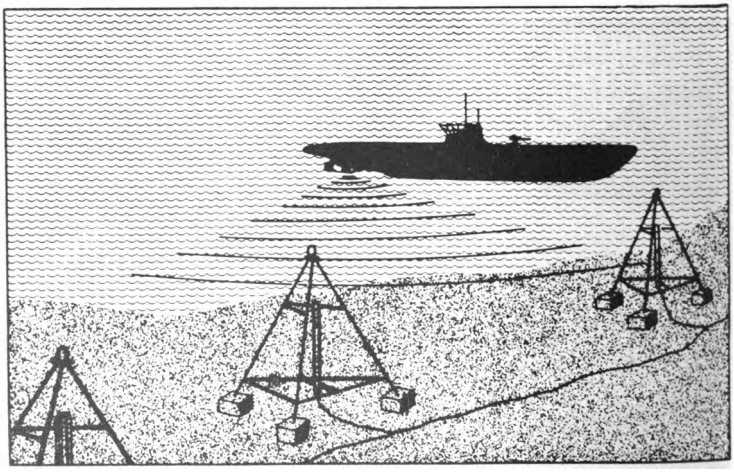

Figure 14–4.—Cable-connected hydrophones.

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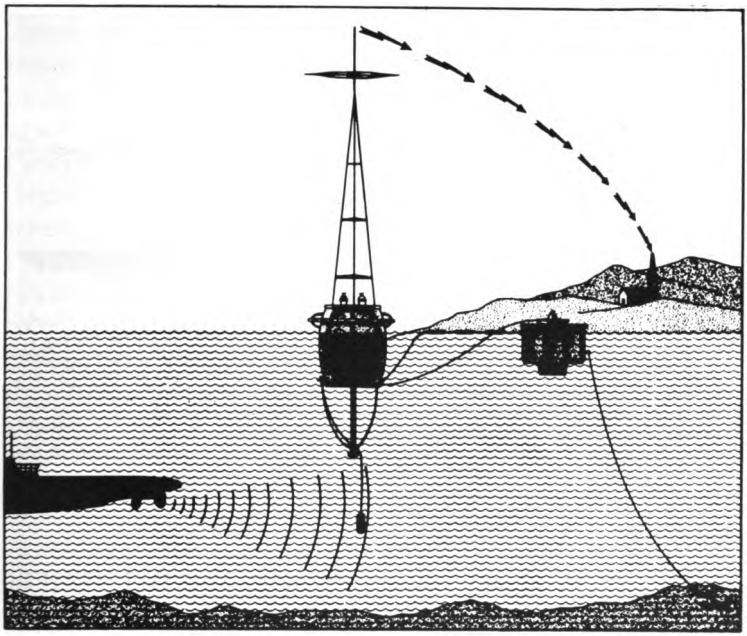

Figure 14–5.—Sonobuoy in operation.

hydrophones or sonobuoys can usually identify the type of vessel and her speed.

As the target continues to move in, it will next be detected by a harbor echo-ranging device called the HERALD. While the hydrophones localize the area of penetration, the herald contact pinpoints the target. In simple terms, the herald is a searchlight-type transducer mounted on a tripod planted at the bottom of the harbor. At the detection station it can be set to search automatically a particular sector, or can be trained manually. See figure 14–6.

A harbor defense Sonarman develops his herald contacts in the same way that shipboard Sonarmen get bearings and cuts on a submarine. The herald not only locates the target but, like shipboard sonar, also tracks it.

Long before the enemy gets within range of the herald, a plot has been started and HECP is alerted. Even as the

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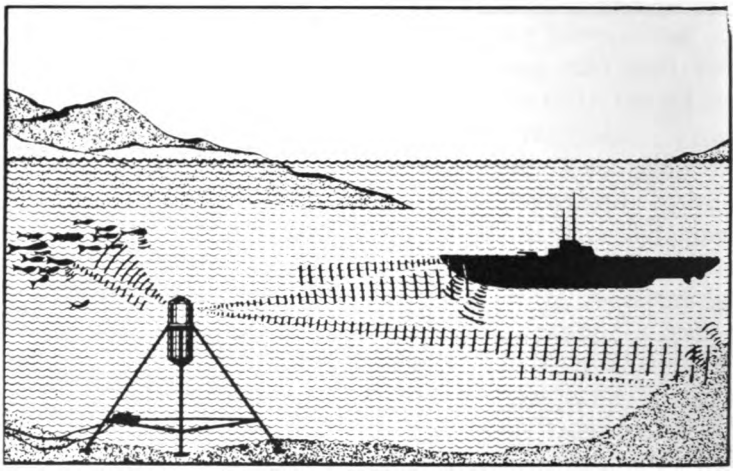

Figure 14–6.—The herald echo ranges on its target.

herald operator develops the target, patrol vessels are on their way to the area, ready to take the offensive and destroy the enemy.

Surface radar is by no means out of the picture during this time. The contact could very well be an enemy warship or a fast surface sneak craft. Furthermore, a good radar operator can pick up a periscope above the surface of calm water at 3000 yards.

DEFENDING A HARBOR

The ideal detection system consists of magnetic loops (or early warning hydrophones) to seaward, hydrophones or sonobuoys to back up the loops, and heralds to back up the hydrophones and sonobuoys. But no one detection system is standard for all harbors, because each harbor differs from the next; and detection systems must be so planned that they meet the needs of the individual harbor.

Here are some of the problems to be solved in planning a harbor detection system. Approaches to the harbor may be too deep for hydrophones. Or heavy seas and strong currents may make it impossible to plant and maintain

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sonobuoys. The lay of the bottom may make it impossible to set up hydrophone tripods, or may cause silt to bury the hydrophone. Minesweeping vessels, streaming electrical gear, can wreck the indication from the magnetic loop. Powerlines on the beach, or the shock of shore-based artillery fire, can prohibit the use of sensitive meters which tell when a magnetic loop detection line has been penetrated.

Fundamentally, these are not your problems since you probably will never be required to plan a harbor underwater detection system. But an understanding of these problems will help you use your equipment intelligently. It will train you to expect different combinations of equipment at each station. For example, instead of a single line of hydrophones inside the magnetic loop line, you may find a double line of sonobuoys. There may be long-range heralds stationed near the approaches to the harbor, and short-range (commonly called short-pulse) heralds guarding the inner harbor.

Under ideal conditions the detection system will be laid out similar to the one illustrated in figure 14–7. Shown

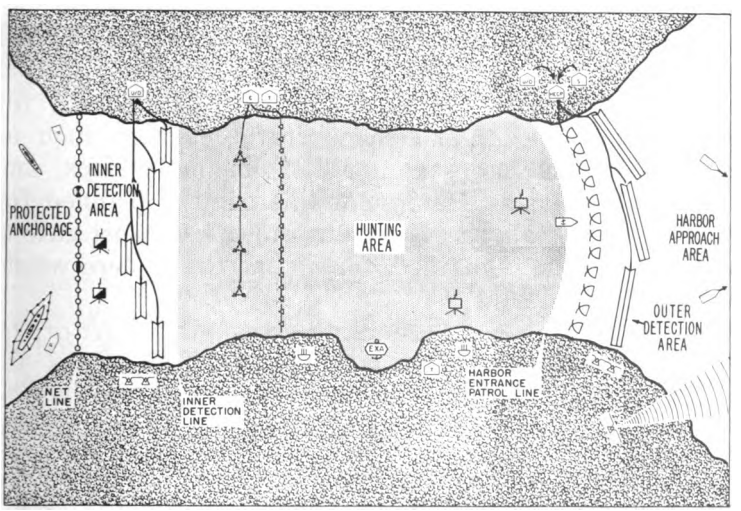

Figure 14–7.—A plan for naval harbor defense.

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are five areas from the anchorage seaward: protected anchorage, inner detection area, hunting area, outer detection area, and harbor approach area. As you can see, the hunting area may overlap both inner and outer detection areas. Your concern is with underwater detection devices and their control stations ashore. But note also the location of minefields, nets, and radars.

PROTECTED ANCHORAGE.—This is the area where our ships dock and anchor. It is also the area which the enemy wants to penetrate to launch torpedoes and plant mines. How large this area will be depends upon the size of the harbor, the number of ships it can handle, whether it's a stateside port or an advance base, and so forth. In addition to the detection system, this area is nearly always protected by nets, booms, and minefields. The dividing line between the protected anchorage and inner defense area is generally referred to as the net line.

Defense areas seaward of the net line are designed to prevent enemy vessels from destroying the protection of the net line, and to prevent them from firing torpedoes or attempting passage through an open gate. This means the outer detection line will always be to seaward a distance greater than effective torpedo range, topography of the harbor permitting.

INNER DETECTION AREA.—This area is reserved for special small-object and sneak craft detectors such as small-object surface search radar, magnetic loops, and short-pulse heralds. Defense at this point is planned for detection of small, slowly moving objects. The net gate is especially heavily guarded, for a penetration here would bring serious results.

HUNTING AREA.—The hunting area is that part of the outer harbor patrolled by surface craft. These ships are equipped with echo-ranging sonar and are on the alert to investigate all contacts. At HECP these craft are tracked by radar, and their positions are plotted against the position of the enemy contact as maintained by heralds and other detection equipment. HECP stands ready to pre-

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scribe courses to bring patrol craft within sonar range of the target.

The hunting area is large enough for patrol craft to detect the enemy, and to attack and reattack before he can reach the protected anchorage. The seaward boundary of the hunting area is known as the HARBOR ENTRANCE PATROL LINE.

OUTER DETECTION AREA.—In the outer detection area a complete detection installation, including magnetic loops, hydrophones, and long-range heralds, gives warning of any invader as small as a midget submarine. Surface-search radar covers this area to determine immediately whether UD's contacts are surfaced or submerged.

HARBOR APPROACH AREA.—Inbound vessels first come under HECP control at the entrance to the swept channel. Surface detection radars constantly search and track targets in this area, supplying information to HECP. Inbound vessels must identify themselves before reaching a position from which they could fire torpedoes at the harbor entrance or block the entrance by mining or scuttling. HECP sends maneuvering instructions to the vessels, ordering them to keep clear of danger areas, and even ordering them back to sea. Inbound vessels may be ordered to the examination anchorage (shown in fig. 14–7), at advance bases and strictly military ports, by the naval port control officer.

Surface Patrols

The harbor defense commander of a large port controls three types of surface patrols: harbor entrance, inner harbor, and inshore. Harbor entrance patrols are continuously on station at the seaward end of the hunting area. They are antisubmarine craft equipped with radar, sonar, depth charges and other A/S weapons. The inner harbor patrol is usually divided into an anchorage-and-waterfront patrol and a net patrol. Lightly armed craft such as 45-foot picket boats are provided for this patrol. The anchor-

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age-and-waterfront patrol operates within the anchorage area to protect ships and harbor installations against attacks by sneak craft, swimmers and saboteurs. The net patrol watches the net lines and net gates to prevent cutting and/or penetration of nets and gates by craft or swimmers. Inshore A/S patrols are stationed near swept channels to detect and destroy submarines attracted by concentrated shipping at the entrance to the harbor. Because the approach to the harbor offers many targets for submarines, daylight air patrols supplement round-the-clock surface patrols in the area.

Minefields

In harbor defense, mines are used principally against large submarines attempting to sneak through the defensive system. They are not particularly effective against small craft such as motor torpedo boats and midget submarines. Minefields deny passage to enemy surface and subsurface vessels, attempting to penetrate the harbor.

There are three types of defensive minefields: interception, exclusion, and antisubmarine trap. The interception field is laid as a threat to vessels taking routes objectionable to harbor defenders. The exclusion field denies passage to all ships; and the antisubmarine trap, as the name implies, is laid to destroy submarines.

The standard controlled mine in harbor defense is actuated (that is, armed) by the magnetic field of a passing vessel, but it usually is fired only at the will of an operator in the shore station. When the mine is actuated (and thus is ready to fire), hydrophones, planted to seaward of the mines, send impulses to the control station ashore. At the control station, the impulses are translated into graphic indications on a recorder, oscilloscope indications on a cathode-ray tube, and an audible signal through a loudspeaker. The operator knows exactly what armed the mine, and his evaluation is relayed to HECP, where the decision to fire will be made. A controlled mine can also

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be set to fire automatically at the approach of any target, without a decision from the control station; or it can be fired from shore, whether or not a ship has actuated it.

Operation of shore control panels of mine acoustic systems is a job for which harbor defense Sonarmen are trained.

Communications

The nature of harbor defense work requires the support of good communications. An antisubmarine vessel carries with it the facilities for detecting, tracking, and destroying an enemy submarine. In harbor defense, the same job is done by several units widely dispersed over the harbor area. The target is detected by one component of harbor defense, tracked by another, and destroyed by a third. Teamwork required is possible only with good communications.

Harbor defense relies heavily on telephone communications. Units and components of the defense system share telephone command circuits. Remote and mobile units are reached by radiotelephone or visual signaling, where phone connections are not possible. Teletypewriter landlines tie in HECP with the nearest communication center, but ordinarily do not link units of the defense forces. Patrol vessels, gate vessels, minesweepers, and other harbor defense craft exchange information with HECP by radiotelephone and visual.

Communication between the UD stations and HECP is by telephone. In addition to the direct line from herald operators to the A/S plot, there is a switchboard phone connection between UD watch officer and HECP watch officer. Information from radar station to HECP, and from radar operators to the radar plots, is also passed by telephone.

Surface Surveillance

The surface surveillance component is responsible for detecting surface targets and low-flying aircraft in the

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harbor defense area. It is made up of radar elements, searchlight batteries, and visual lookout stations. The main source of information on surface targets is radar, and you can expect the installations to vary according to the particular requirements of your harbor. There will be fixed radar installations, supplemented (as necessary) by mobile units. Radar types include general search, capable of detecting air and surface targets, and short-range radar, capable of detecting small targets. Certain radars help control harbor traffic in low visibility.

Searchlight batteries assist in surface detection and identification at night; visual lookout stations do the same by day. All surface surveillance elements are controlled at HECP.

HECP Plots

Two types of plots are maintained in HECP for display and evaluation of harbor defense data. The SITUATION PLOT (SUMMARY) is maintained on a large magnetic plotting board, with positions of targets indicated by small color-coded magnets. This plot presents an over-all picture of activity in the defensive sea area. Positions of all targets are plotted by grid coordinates.

The HECP plot with which you will be directly concerned is the ANTISUBMARINE (tactical) PLOT. It is kept on a large board showing details of the harbor area. Positions of inshore patrol vessels, as furnished by the SO radar, are plotted here. This plot also includes information on underwater targets sent to HECP by the underwater detection station.

Here is what happens when you report a contact to HECP: Assuming contact has been made by the magnetic loops, you immediately report the signature, and a plot is begun. Although the exact position of the target is unknown, the (tactical) plot will locate the target on a line approximately 3 miles long (depending, of course, on the length of the loop). The plot will indicate the loop crossed, and the time the crossing began and ended.

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A followup report of contact by cable-connected hydrophones or sonobuoys will help HECP localize the position of the target. Relative intensity of prop beats on two or more hydrophones or sonobuoys gives A/S plotters valuable information for estimating target position.

Once the heralds have contact, the position of the target can be pinpointed. Successive ranges and bearings from the heralds will shortly reveal the target's course and speed. It is then a simple matter to vector surface patrols and aircraft to the point of interception.

Remember, herald ranges and bearings are true ranges and bearings FROM THE HERALD SEA UNIT. At each herald position on the A/S plotting board there is a pivot socket into which a range arm can be fitted. There is also an azimuth circle centered about each herald position. Range arms and azimuth circles simplify plotting ranges and bearings from the herald sea unit.

The A/S plot is geographic, and is kept in the same manner as a shipboard DRT plot. Except for the initial contact report, herald operators report their ranges and bearings directly to the A/S plot via telephone.

STATUS BOARD.—A record of the over-all harbor defense situation is posted on a status board in HECP. All ship arrivals and departures, as well as estimated times of arrival (ETA) and departure (ETD), are logged on the board. Other information on the status board reveals at a glance what ships and planes are on patrol, and the sectors they are patrolling. From the board the Harbor Defense Officer (HDO) can instantly verify the status of net gates and minefields. The latest weather information—visibility, wind, sea, etc.—is also posted. Finally, the status board furnishes a record of equipment failures, especially those which weaken the defense of the harbor area.

UD WATCH STANDERS

The underwater detection officer (UDO) is in charge of the detection station. His assistant is the leading Sonarman, who may serve as UD watch officer.

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The Sonarman supervisor, under the UDO, directs the use of all detection station equipment. He gives herald operators search sectors, and prescribes keying intervals according to standing instructions. He receives reports from the watch standers, makes preliminary evaluation, and passes the information to the UDO. As watch officer, he will transmit information directly to HECP. Once underwater contact is made, he is responsible for a steady flow of information to HECP. Even though the herald operators have direct phone connections to the A/S plot, the sonar supervisor relays the first report of a herald contact. When the loops indicate presence of the enemy, he estimates the hydrophones and/or buoys on which additional contact can be expected. He makes sure operators are particularly alert on those hydrophones and buoys. In short, he sees that the men stand taut watches and make the best possible use of detection equipment.

He also maintains the detection station rough log, recording each contact, the time, and the action taken.

As an equipment operator in the UD station, you may stand months of quiet, monotonous watches and nothing happens. You will monitor and identify the water noises of every power craft that moves in and out of the harbor. In time, you will know the sounds of the harbor as well as you know sounds that come from a familiar room. Through it all, you must remain vigilant. Report every sound, and the beginning of every loop signature. A submarine attempting to penetrate the harbor will be rigged for silent running, with all unnecessary auxiliaries secured. She may try to drift in with engines dead. Never forget: Sounds the enemy makes are apt to be extremely faint.

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QUIZ

1. To whom is the harbor defense commander responsible for the effectiveness of his unit?
2. What is the relationship of the harbor entrance control post to the harbor defense unit?
3. Name four types of equipment located in the underwater detection station.
4. What line divides the protected anchorage from the inner defense area?
5. The seaward boundary of the hunting area is known as what line?
6. The harbor defense commander of large ports controls what three types of patrols?
7. Name the three types of defensive minefields.
8. The surface surveillance component of harbor defense is made up of what three elements?
9. What two types of plots are maintained in HECP for display and evaluation of harbor defense data?
10. What is the purpose of the status board in HECP?
11. What officer is in charge of the detection station? Who is his assistant?

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CHAPTER 15

MAGNETIC LOOPS

MAGNETIC DETECTION

The MAGNETIC DETECTION LOOP is a fixed underwater system designed to detect either surface or underwater vessels approaching a harbor or other vulnerable area. Basically, it is a magnetic flux-measuring circuit. From your knowledge of electricity you know that magnetic flux is another term for magnetic lines of force.

The loop is laid at the entrance to the harbor and is connected to a RECORDING FLUXMETER located at the detection station ashore. Each installation is made up of three single-conductor cables laid parallel and approximately 600 feet apart to form a loop (fig. 15–1).

When correctly laid and properly operated, the loop is a very sensitive device. The distortion of the earth's magnetic field by a metal object, such as a submarine, crossing the cable causes magnetic unbalance between the two areas enclosed by the cable. This generates small currents which are indicated on your fluxmeter.

One of the greatest advantages of the loop is that it can protect stretches of water up to 6 miles in width. In actual practice, loops have been laid as short as six-tenths (0.6) mile and as long as 6.3 miles. The average length is between 2 and 3 miles. The shorter the loop, the easier it is for you to localize the point where a vessel crosses it. An-

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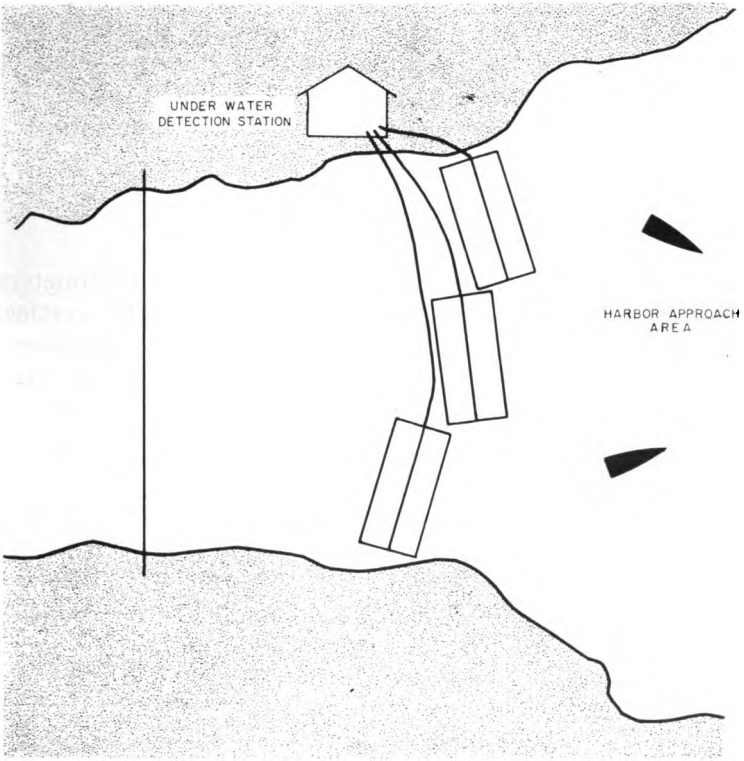

Figure 15–1.—The magnetic detection loop.

other thing, short loops can be operated at higher sensitivities.

Any ship or sub that crosses your loops "signs in" on the fluxmeter recorder paper, so the trace which the pen makes on the paper is called a SIGNATURE. A good operator never doubts the beginning of a signature. He reports it immediately and then proceeds to analyze it. The sooner HECP gets word of the target, the faster patrol craft can be dispatched to intercept it. There was a case in World War II when an operator spent more than 8 minutes trying to decipher a signature. In the meantime, the midget submarine had released its torpedoes within the harbor.

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Operation of the fluxmeter controls is an exact procedure, and you've got to know what you are doing or you'll damage the equipment. If you handle it right, the equipment will give you long, uninterrupted service, but it will stand very little abuse.

RECORDING SIGNATURES

The ruled portion of the chart paper is 100 millimeters (mm) wide (slightly less than 4 inches). The vertical lines are numbered from zero (at the center of the chart) to 50 mm in each direction. There are five vertical divisions, marked off in increments of 10, to either side of zero. Each 10-millimeter division is ruled into five spaces of 2 millimeters each.

The pen rests at zero on the chart when there is no magnetic disturbance over the loop. As a ship crosses the loop, the pen moves to the right or the left, recording the amount of flux. The larger the ship, the greater the pen deflection. Therefore, by lining up the trace on the chart and reading the deflection scale, you can tell what the approximate size of the target is.

The curved lines across the chart are one-half inch apart and correspond to the curve or arc the pen makes in full-scale deflection across the chart. In other words, if the pen moved all the way to the right or left (0 to 50 mm) the line it printed would parallel the curved lines across the chart.

The chart paper travels downward at a speed of 1 inch PER HOUR when the recorder is idling—that is, not recording a ship's signature. When a ship starts over the loop, the pen begins to move away from zero. The pen touches an electric contact and a high-speed motor instantly takes over, increasing the chart speed to 1 inch PER MINUTE. Knowing the chart paper speed, you can calculate the speed at which a ship is traveling by reading the elapsed time between points in the signature. These points correspond to the progress of the ship over the legs of the

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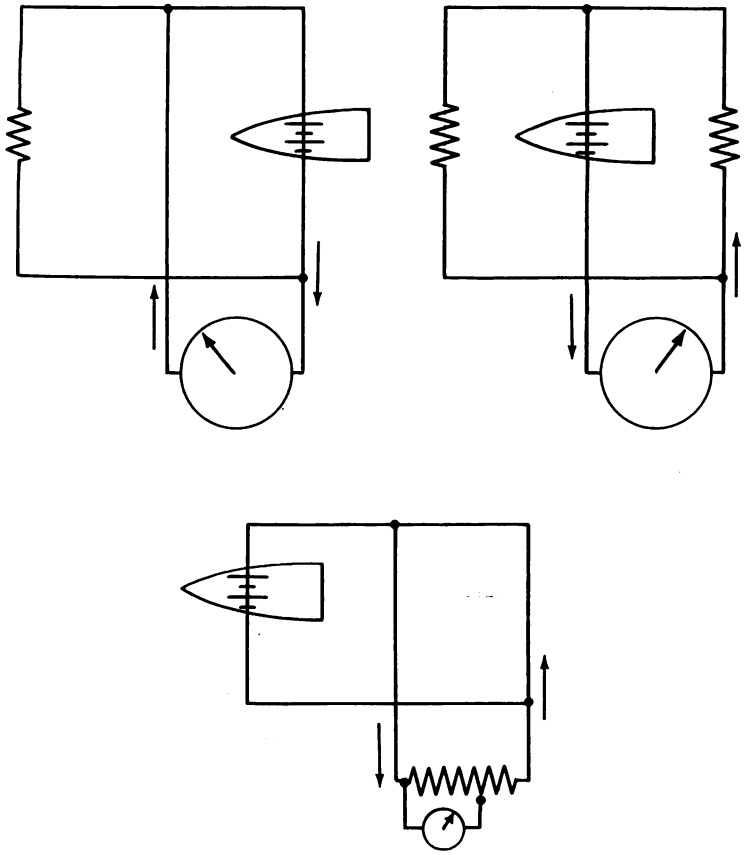

Figure 15–2.—Current flow as ship crosses loop.

loop. Figure 15–2 shows current flow and resulting needle deflection caused by a ship crossing a leg of the loop. The needle returns to center when the ship is between legs, and deflects again as the ship crosses the center leg of the loop.

When the pen moves away from zero, causing the high-speed motor to start, a buzzer sounds a warning so that the operator knows immediately that a target is crossing the loop.

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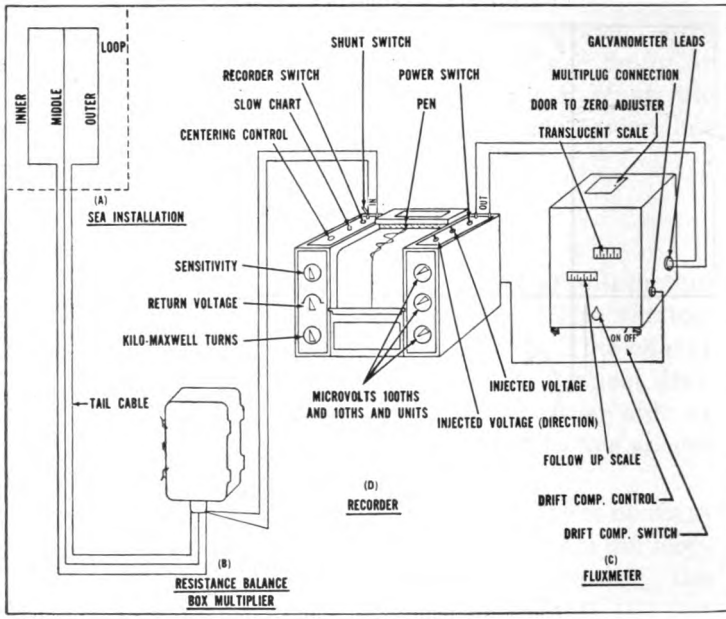

Figure 15–3.—The fluxmeter installation.

FLUXMETER OPERATION

There are 12 steps in the operation of a fluxmeter, beginning with SIGN ON. Refer to figure 15–3 with the discussion of each step after SIGN ON.

Sign On

Figure 15–4 shows a sample of the recorder chart paper on which signatures are recorded. Note that all the details of a watch are entered directly on the recorder chart paper. Thus each completed roll becomes a permanent file.

When you begin a watch on a fluxmeter, draw a line across the paper exactly at the point where the pen is and SIGN ON above the line. Give the hour and date the watch starts, always using Greenwich mean time.

Steps Nos. 2 and 3, precautions taken to keep from damaging your equipment when the recorder switch is

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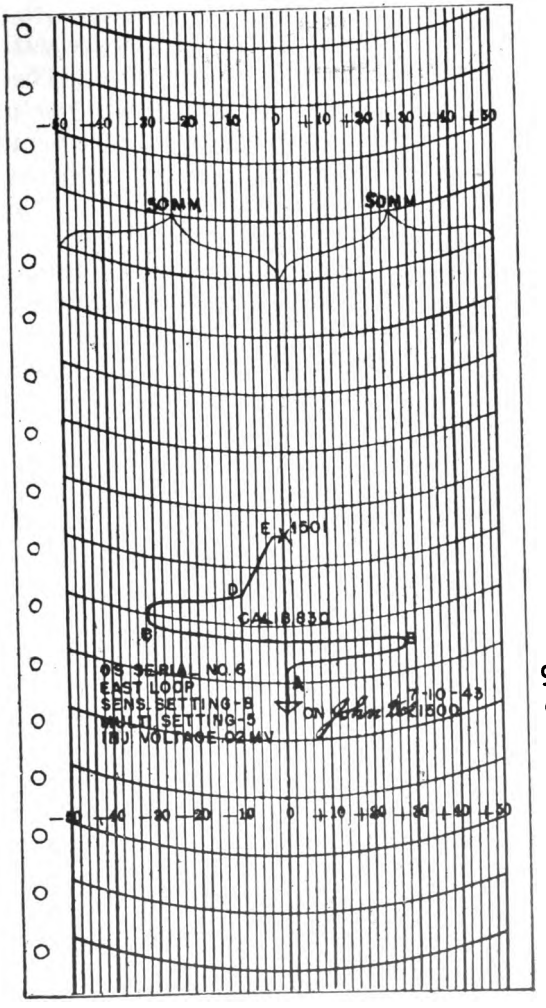

Figure 15–4.—Calibration signature.

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turned on, are: PLACE CENTERING CONTROL TO OFF, and TURN SENSITIVITY CONTROL TO ZERO.

For steps 4 through 10, refer to figure 15–3.

In step No. 4 you center the galvanometer with the return voltage control. When you do this, you are setting the galvanometer coil exactly in its zero position. The coil is suspended between two pole pieces. When you put the galvanometer coil in its zero position you are bringing it into perfect central alignment with the axis of the two pole pieces. If you fail to do this, you would get a violent disturbance of the pen when you turned on the recorder switch. The equipment is so designed that the pen assumes the same position relative to its zero point as the galvanometer coil is to its zero position. The pen moves to that position the instant the recorder switch is turned on. If the galvanometer coil is not at zero, there's a good chance you'll damage the equipment.

The deflection distance of the pen is magnified many times over that of the galvanometer coil. This means the coil need be only a slight distance away from zero to cause a considerable jump of the pen. The pen unit is fragile; a violent jump from the resting point (zero) to somewhere near the outer limits of the chart would wreck it.

You can check the position of the galvanometer coil by observing the position of the round beam of light on the translucent scale in the front of the fluxmeter case (C in fig. 15–3). A light beam is directed against a mirror attached to the top of the coil and is reflected to the translucent scale. Turn the RETURN VOLTAGE CONTROL left or right and you can deflect the galvanometer in the direction you want to bring the light beam to the exact zero point in the center of the scale.

Don't be alarmed because turning the return voltage control in one direction causes the light to move in different directions at different times. This circuit is in the INJECTED VOLTAGE CIRCUIT (see right side of recorder case in fig. 15–3). The direction of the circuit can be changed from one side to the other by reversing the polarity

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switch. If the first turn of the control moves the light beam in the wrong direction, simply turn the control to the opposite side.

This completes the four preliminary steps which you must take before turning the recorder ON. Now, before the galvanometer can slide away from zero, follow through with step No. 5 by holding the pen and turning the recorder switch on.

Hold Pen and Turn Recorder Switch On

There is a special way of holding the pen when turning on the recorder. Place two fingers of the right hand on the recorder writing table, allowing the fingers to straddle the pen with about an eighth of an inch clearance on either side of the pen. When the recorder is switched ON the pen will strike your finger instead of a contact point. A pen can be bent into an L-shape from striking a contact with force. When you get ready to cushion the pen, be sure not to touch any contact points, including the silver sleeve on the pen shaft.

Of course, if you get a perfect alignment of the galvanometer, the pen won't deflect when you turn on the recorder. As a general rule, however, the pen will deflect to one side and then, a second later, will bob back and forth a few times before coming to rest. This means the FOLLOW-UP ELEMENT which controls the pen's movements is settling to its proper alignment with the galvanometer coil. This is known as TRACKING THE GALVANOMETER.

In the sixth step you center the pen with the MANUAL setting of the CENTERING CONTROL.

Turn the centering control toward the left from OFF to MANUAL. If the OUT terminal leads from the recorder to the galvanometer have been connected with the correct polarity, the pen will return to zero from whatever point it may have come to rest. You have no means of knowing the correct polarity except by the trial-and-error method. Should the MANUAL setting of the centering control cause the pen to deflect to one side of the chart paper and stay

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there, turn the recorder switch off, reverse the OUT terminal leads, and start again with step No. 2.

If you don't hold your fingers close enough to the pen, it may deflect far enough to crash into an inner contact point. This would cause the high-speed motor to start. In such case, press the SLOW CHART button to stop and disengage the signature motor after the pen is returned to zero.

In step 7 you open the shunt switch.

To protect the equipment from any induced voltage from the loop while not in regular operation, a shunt or shorting switch is usually placed across the leads from the loop. This may be a knife switch across the recorder IN terminals or some other type of all-copper switch. A signature voltage can enter the unit only after the shunt switch is opened.

In step 8 you turn the centering control to AUTOMATIC. It must always be in this position for operating.

In step 9 you place the sensitivity control at the proper setting.

The exact function of the sensitivity control needs some explanation. When a ship crosses the loop, it sets up a deflection in the galvanometer. The pen duplicates the movements of the galvanometer and writes the signature on the chart. The sensitivity control establishes the ratio between the galvanometer coil and the recorder pen. It magnifies the galvanometer deflection so that the pen writes on a larger scale, making it easier for you to read the signatures.

All you do is place the sensitivity control at a setting previously determined by the watch officer or the maintenance man. This may be any point from zero to 10.

About twice a week you have to check your equipment for a change in operating sensitivity. This requires calibration of the unit, which is step No. 10.

Calibration

Within the recorder there is a constant-value flux-cutting unit. It is called the KILOMAXWELL TURNS unit and its

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purpose is to simulate the action caused by a ship crossing the loop. In other words, turning the control (bottom left on the panel) will give you a signature on the chart. The control revolves a small permanent magnet inside a coil of wire. The coil cuts the lines in the magnet's field and induces a voltage which causes the pen to deflect. The unit is so designed that 20,000 flux lines are cut when the magnet is turned one full revolution.

A calibration signature with sensitivity control setting at 5 is shown in figure 15–4. The signature starts at point A, where the pen rested at zero, and finishes at point D. This signature, with a curve on each side of zero, is made by turning the control clockwise one complete revolution. To get the proper magnitude of signature, rotate the control in a steady, smooth manner at a speed of 4 rpm (15 seconds for the full revolution). At this speed, the pen's movement and its friction against the paper won't distort the size of the curves.

The sample calibration signature shows the pen coming to rest at point D, not quite back to the zero line. This is caused by turning the control too slowly. From D to E marks the course of the pen making its natural drift toward the zero line. At E a straight line goes directly to zero. This was caused by turning the centering control to MANUAL. Anytime you turn this control to MANUAL, the pen will immediately return to zero from whatever point it happens to be. When the pen returns to zero, the control must be switched back immediately to AUTOMATIC. Anytime the pen is brought to zero, the chart is marked with an X and the time is entered. (In the illustration the time is 1501.) Remember, every mark of the pen must be identified and accounted for.

Frequently the pen does not return to zero after following a ship's signature. It is then necessary to switch the centering control to MANUAL. However, if the pen is away from zero, always permit it to drift for 2 minutes after each ship's signature. This will keep you from distorting

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the signature of a submerged enemy submarine which may be trying to sneak into the harbor behind a friendly surface ship.

Let's assume that the sample signature curve shows the proper speed of operating the kilomaxwell turn control. The pen reaches its deflection peaks at 28 mm to the right of zero and 32 mm to the left. The deflection amounts to a total of 120 mm.

28 mm from zero to peak (right.)
28 mm from peak back to zero.
32 mm to peak (left).
32 mm from peak back to zero.

120 mm total.

By dividing 120 mm into the 20,000 lines cut, you learn that, in this case, each millimeter deflection of the pen cuts 166 lines. This gives you a unit of measurement against which to compare the magnitude of the pen's deflection (maximum deflection) on a ship's signature.

To get a watch started with the least possible delay, the operator can use a shortcut for determining the unit of measure. The peak points are added together (in this case, 28 mm plus 32 mm) and divided by 10,000 lines instead of 20,000. The answer will be the same.

Before logging this figure (166) on the chart, you have to take into consideration the MULTIPLIER setting.

The Multiplier

The multiplier is the unit which determines just how much of the voltage induced in the loop will be allowed to enter the fluxmeter. The multiplier has five possible settings: 1, 5, 25, 125, and 625. These settings establish the ratio between the loop voltage and the amount of voltage permitted to enter the fluxmeter. (Although it is called a multiplier, it functions, essentially, as a voltage divider.)

If the No. 1 setting is used to link the loop with the meter, then all the loop voltage is allowed to come in. At the No. 5 setting, only one-fifth of the voltage is allowed

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in; at No. 125, one twenty-fifth; and so on. The multiplier setting depends upon the location of your station, the depth of the loop, and the general size of traffic passing over the loop.

If the setting is No. 5, only one-fifth of the voltage will get in, so the signature will be only one-fifth the size it would be if ALL the voltage were allowed in. To figure the correct size of the ship making the signature, it is necessary to magnify the incoming signature five times.

Here's where the calibration figure (166) comes in again. You simply multiply the calibration figure by the multiplier setting and come up with a single operating sensitivity figure. (In our example, this figure is 830.) You can apply this against all ship signatures. In other words, each time a ship deflects the pen 1 mm, it is cutting 830 lines of magnetic flux. The larger the ship, the more lines cut, and the greater the pen's deflection on the recorder chart.

As operator of the fluxmeter, you are allowed only 30 seconds from the time the signature ends until a full report is made. This doesn't seem like much time; but a good operator can do the job easily in that half-minute.

Once you have the operating sensitivity figure you enter it on the chart beside the word "Calib." You can then record the rest of the chart data (step 11).

Five additional entries complete the record (refer to fig. 15–4):

1. Identify the recorder and the fluxmeter in operation.
2. Identify the loop to which the recorder is attached.
3. Record the sensitivity control setting.
4. Record the multiplier setting.
5. Record the amount of injected voltage.

The Injected Voltage

The INJECTED VOLTAGE comes from a 1.5-volt dry cell battery inside the recorder. It is used to maintain the

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resting or idling course of the pen on the zero line of the chart when no signature is being recorded. It compensates and offsets any idling course which is slightly away from the zero line. The galvanometer may not quite be at the zero position, and the pen, likewise, would be away from zero.

If the distance from zero is only slight it can be corrected by injecting a few tenths microvolts into the galvanometer coil circuit. In this way it's possible to continue your watch without interrupting it to make slight adjustments to the galvanometer zero.

The voltage must be injected in the right direction. A control is provided which is marked with a directional arrow on each side, showing in which direction the voltage is injected to bring the pen to zero. Turn the control to the right-hand position if the pen rests slightly to the left of zero, and to the left position if it rests to the right of zero. Keep in mind that the injected voltage control is used to center the pen only if a FEW tenths microvolts will do the trick.

The Log

The final step is to log your watch. The exact type of log to be kept will vary with different stations. In any log, however, you will be required to enter all the data on the chart paper for each signature, plus any other details concerning the signature. Make your entries as soon as the signature comes in. Be sure to log information concerning the type of ship and probable direction of travel.

SUMMARY

Here is a summary of the steps for operating a fluxmeter. Memorize them if it will help, but you will retain the information only if you know the purpose and meaning of each step. The steps are as follows:

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1. Sign on.
2. Set centering control to OFF position.
3. Turn sensitivity control to zero.
4. Center galvanometer with return voltage control.
5. Hold pen and turn recorder switch to ON.
6. Turn centering control to MANUAL position. If necessary, press SLOW CHART button after pen reaches zero.
7. Open shunt switch.
8. Turn centering control to AUTOMATIC position.
9. Place sensitivity control to proper setting.
10. Make calibration.
11. Enter chart data.
12. Enter log data.

QUIZ

1. What is another term for magnetic flux?
2. What instrument is used to measure the cutting of flux lines?
3. When a ship crosses a magnetic loop it SIGNS IN. What is the recorded indication at the detection station called?
4. Why does a small deflection of the galvanometer coil cause the pen to move a much greater distance?
5. What is the function of a shunt switch?
6. What is the significance of the multiplier setting?

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CHAPTER 16

HYDROPHONES AND HERALDS

A hydrophone is a sensitive listening device which picks up underwater sounds and transmits them by submarine cable to receivers in the underwater detection station. You first learned about hydrophones when you studied shipboard sonar equipment. As every Sonarman knows, the transducer of his sonar set functions as a hydrophone every time it picks up an underwater echo.

There are two types of cable-connected hydrophones employed in harbor defense. First, and oldest, is the JR 1 planted in the sonic line, and second, the Mk 5, planted to seaward of controlled minefields.

JR 1

The underwater portion of the sonic hydrophone system includes one or more tripod-mounted JR 1 hydrophones placed on the ocean bottom and connected to the UD station by armored submarine cable. (See fig. 16–1.) They are spaced not more than 1000 yards apart and can detect sounds from a slowly moving submarine even in the presence of a noisy surface vessel. They operate satisfactorily in pressures up to 400 pounds per square inch or down to depths of 925 feet. Shore station equipment includes a submarine cable terminal box, automatic-manual switching unit with rectifier, high fidelity amplifiers with rectifier, headphones, and necessary connecting cables.

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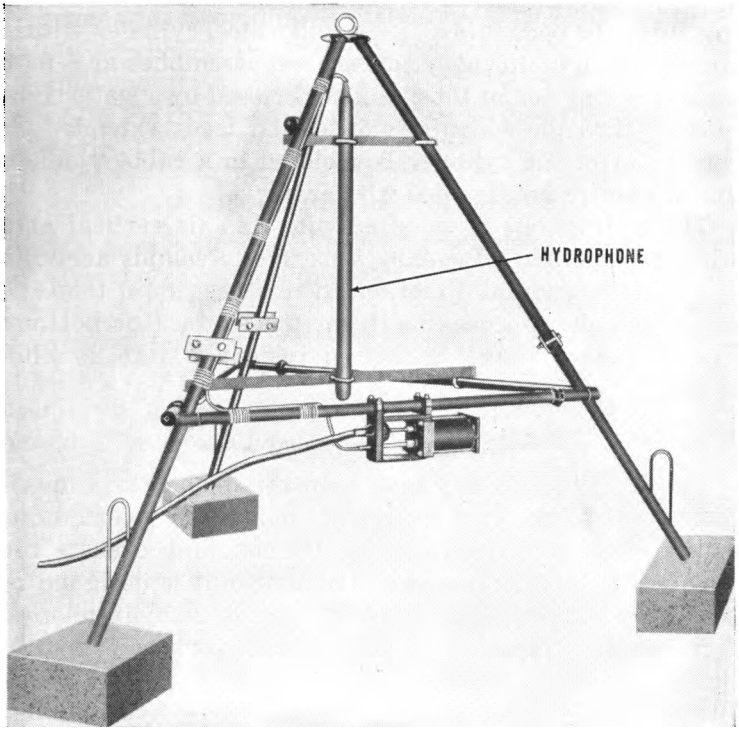

Figure 16–1.—A cable-connected hydrophone sea unit.

Tripods

The tripods are approximately 8 feet on a side, 8 feet high, and are constructed of extra heavy 1½-inch iron pipe. They are designed to hold the hydrophone in a vertical position, with the bottom of the hydrophone approximately 1½ feet above the base of the tripod. Each foot of the tripod is made of a 1-foot cube of concrete weighing approximately 150 pounds.

Hydrophones

The hydrophone used with this type of listening equipment is a cylindrical device approximately 55 inches long

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by 2½ inches in diameter, with a half-inch cable extending from one end. It is a skeletonlike steel cylinder within which are eight Rochelle salt crystal assemblies at 3-inch intervals. One end of the cylinder is closed by a watertight barrier through which two insulated leads extend. The remainder of the cylinder is enclosed in a rubber jacket, and the entire unit is filled with castor oil.

The hydrophone is mounted with its axis vertical and, when so mounted, is equally sensitive to sounds arriving from any horizontal direction. In this position it tends to reject sounds approaching from the surface or bottom. The frequency range of this equipment is 1 to 20 kilocycles.

Auto-Manual Switching Units

Twenty hydrophones have been established as a maximum for one line, even though not more than seven on one string is recommended because the listening cycle is too long. An automatic-manual switching unit is designed to permit the automatic scanning of a line of 20 hydrophones, each one in succession. Controls for automatic scanning include a rotary selector switch, and a motor ON-OFF switch. The numerical designations of the hydrophones are arranged in a circle around the selector switch. See figure 16–2. With the switch in the ON position, scanning

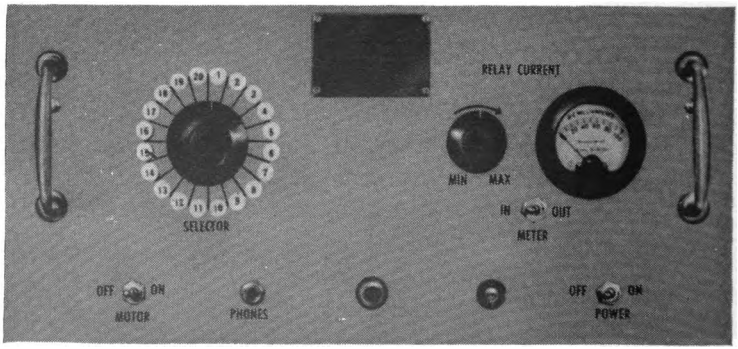

Figure 16–2.—Auto-manual switching unit.

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is automatic, providing a listening period of approximately 4 seconds for each hydrophone. You can obtain manual operation when desired by turning the motor switch to the OFF position and rotating the selector switch by hand.

LISTENING TO THE HYDROPHONE

Local water-noise conditions sometimes make it necessary for you to use the amplifier filters for the best signal-to-noise ratio. When conditions permit, the filters should be removed to allow a wider band of signal frequencies to be heard. The sounds will also be easier to identify. When filtering is necessary, use only the minimum amount required.

You should monitor the entire line of hydrophones as often as possible, and yet listen to each hydrophone long enough to allow your ears to become adjusted to the noise level. In that way, no sounds will be missed. Listening tests have been made which indicate that a period of 3 or 4 seconds is the best listening period. For this reason a setting of 3 seconds is recommended for automatic operation. Unusual conditions may force you to use a longer, or possibly a shorter, listening period.

Always practice identifying the sounds you hear. If your detection station is located where you can see surface vessels as they cross the hydrophone line, you can soon learn to identify the different types of vessels by their characteristic sounds.

When an enemy attempts to enter, chances are he won't give off much sound. He may try to drift in, using his engines only now and then to keep on course. To make detection even more difficult, he will probably wait for reasonably rough weather so the high water-noise level will mask the noise of his vessel. If the vessel is a sub, the skipper will probably attempt to enter while submerged, and in the wake of one of our own surface vessels. This would further obscure the sounds of his motors.

Keep all this in mind, and listen carefully. Try to in-

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terpret every sound you hear, remembering that the weakest sounds may be the important ones. You should have the headphones clamped firmly over both ears, and the amplifier gain adjusted to a comfortable level. When you hear a sound you cannot identify, close the key switch for the hydrophone on which the sound is heard and continue listening until you identify it.

SAFETY MEASURES

Always observe these precautions:

1. Keep the hydrophones out of the hot sun, or any location where the temperature will reach 120° F.
2. Handle them with care; rough handling will damage the crystal assemblies, puncture rubber jackets, or break internal wiring.
3. Don't permit oil, acid, or any substance that might damage or deteriorate rubber to come in contact with the jacket.

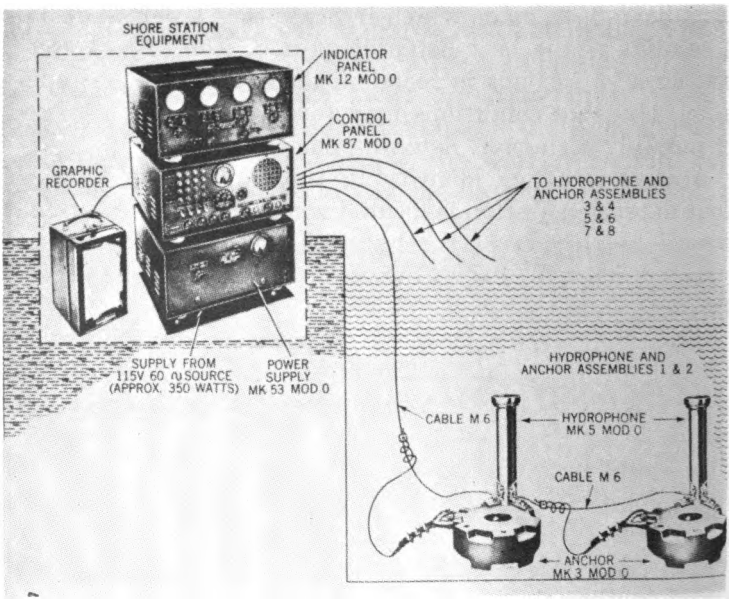
SHORE STATION EQUIPMENT
INDICATOR PANEL MK 12 MOD 0
CONTROL PANEL MK 87 MOD 0
GRAPHIC RECORDER
TO HYDROPHONE AND ANCHOR ASSEMBLIES 3 & 4 5 & 6 7 & 8
SUPPLY FROM 115V 60 ∿ SOURCE (APPROX. 350 WATTS)
POWER SUPPLY MK 53 MOD 0
HYDROPHONE AND ANCHOR ASSEMBLIES 1 & 2
CABLE M 6
HYDROPHONE MK 5 MOD 0
CABLE M 6
ANCHOR MK 3 MOD 0

Figure 16–3.—Acoustic System Mk 6 Mod 0.

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ACOUSTIC SYSTEM MK 6 MOD 0

In chapter 14 you learned that Sonarmen operate shore control panels of mine acoustic systems. The acoustic system which employs the Mk 5 hydrophone is the Mk 6 Mod 0. At the control station it provides graphic indications on a recorder, oscilloscope indications on a cathode ray tube, and an audible signal through a loudspeaker. The system will respond to shellfire, bomb explosions, storms, and other underwater disturbances which might actuate mines. It is relatively easy for an operator to distinguish visual and audible signals from such sources.

Acoustic System Mk 6 Mod 0 is controlled by three interconnected units: a power panel, a control panel, and an oscilloscope panel. In addition, there are headphones and a graphic recorder. See figure 16–3.

POWER PANEL

There are two controls on the power panel, a power switch and a variac control. The power switch (see fig. 16–4) is a single-pole, two-position toggle switch that energizes the power panel. Here is a precaution: Never turn on the power switch until the three control units are interconnected and the control panel is grounded. Unless the power panel is properly loaded, excessive voltages are built up on the filter capacitors, causing their failures. Unless the control panel is properly grounded, dangerous floating voltages may occur in the reception system. A pilot light glows when power is on.

The other control on the power panel is the VARIAC control, which regulates the power supply voltage applied on primary windings of the power transformers. With this control you can compensate manually for some variation of power supply voltage. You can keep the voltage on the primaries of the power transformers at 115 volts with a variation in power supply from 90 to 135 volts. Voltage is indicated on a voltmeter. With the variac control, you adjust it to indicate 115 volts.

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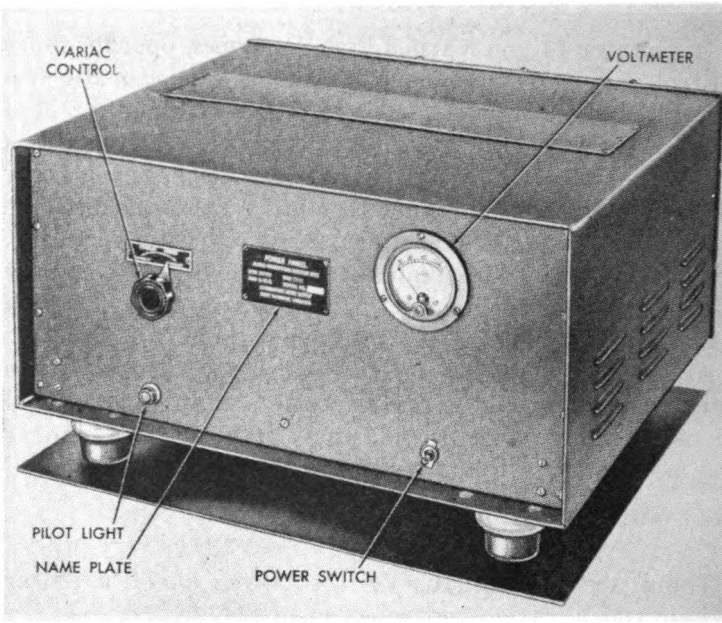

Figure 16–4.—Front view of power panel.

There is no switch for the voltmeter, nor is there one for the pilot light.

OSCILLOSCOPE PANEL

Before we consider oscilloscope panel operation, study the front view shown in figure 16–5. Note that there are four cathode-ray oscilloscope tubes, numbered 1 through 4 to indicate the associated shore cable circuits. Visual signals on the four screens provide a quick comparison of signals from four pairs of hydrophones. Five potentiometers control the signal image on each screen. All five must be adjusted properly for each screen to obtain a satisfactory signal trace for comparison with other screens. If the trace on any screen is not exactly horizontal, rotate the tube until the trace is horizontal.

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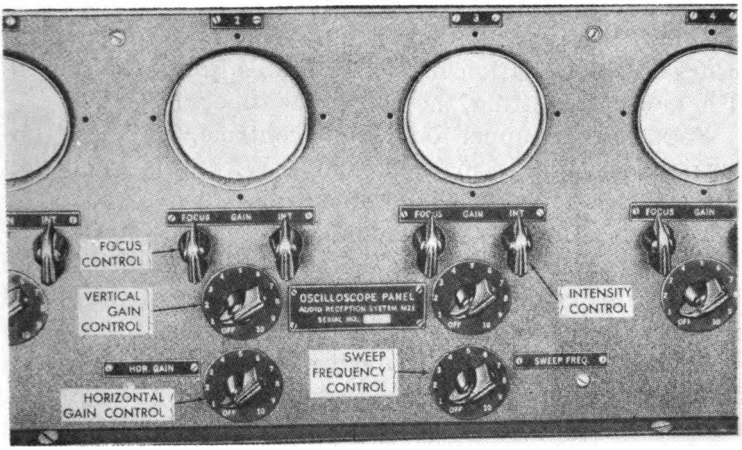

Figure 16–5.—Closeup of controls on oscilloscope.

Each screen has two position-adjusting potentiometers for horizontal and vertical positioning of the signal image. Once adjusted, these potentiometers seldom require further attention. They are placed behind the front panel intentionally to forestall unnecessary knob twisting.

Front Panel Controls

INTENSITY CONTROL.—Three potentiometer control knobs are located beneath each oscilloscope screen. The upper right knob of each set controls the intensity (brightness) of the associated screen and is marked INT. Intensity of the signal image is raised by slowly turning this knob clockwise until the beam become visible. If you turn the control to maximum intensity and the beam does not become visible, an adjustment of the positioning controls will be necessary to bring out the beam. The best adjustment of this control is the MINIMUM INTENSITY WHICH ALLOWS YOU TO SEE SIGNAL IMAGE EASILY. If the beam produces only a spot instead of a horizontal line, quickly turn down the intensity of that tube. A small bright spot will burn a hole in the screen within a few

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seconds. Here is another point: The intensity setting bears a direct relationship to the usable life of the screen. The lower the setting, the longer the tube will last.

FOCUS.—The upper left knob controls the focus potentiometer and is marked FOCUS. With this knob you bring the trace to as sharp a line as possible.

VERTICAL GAIN.—The central knob, marked GAIN, controls the vertical amplitude of the screen included in the trace. This distance is the vertical amplitude of the signal image. When you hear only sea noises, adjust the gain to bring the signal height to about one-eighth to one-fourth inch.

Horizontal Gain and Sweep Frequency

The two remaining controls apply to the oscilloscope panel, and not to a particular screen. The HORIZONTAL GAIN CONTROL, marked HOR GAIN, controls the width of the image. Adjust the gain so the trace just reaches across the diameter of the screen. Clockwise rotation lengthens the trace.

The SWEEP FREQUENCY CONTROL, marked SWEEP FREQ, affects the shape of the trace on the oscilloscope screens produced by any submarine sound or combination of submarine sounds. Primarily, the four oscilloscope screens provide a quick comparison of signals from the four pairs of hydrophones. For this purpose, the setting of the sweep frequency control is not important, except that you may need to adjust it to get a satisfactory trace for comparing the signals on the four screens. With experience, you may be able to get additional information on a submarine sound by observing the sweep frequency setting and the resulting shape of the trace. Even so you don't get a signature from the screen; the graphic recorder provides that.

CONTROL PANEL

Outstanding features of the control panel are a bank of 16 signal lights, four switchboard lever keys, and four

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attenuator knobs. The signal lights belong to the protective and alarm relay system and indicate the condition of four circuits controlling eight Mk 5 hydrophones. The lever keys have three positions (1) OFF, (2) VIDEO (ON) and, (3) AUDIO, VIDEO (ON). The circuit is tested by using the meter insertion switch. When testing the lever keys must be in one of the two "ON" positions. The attenuators control the audio portion of the circuits.

Switchboard Lever Keys

Lever keys are numbered 1 through 4, and each is aligned with a vertical row of four signal lights. (See fig. 16–6). Each key has three position: raised, normal, and depressed. The central (horizontal) position is normal. In this condition the signal of the associated shore cable appears on its oscilloscope screen but the signal is not fed into the audio system. It will not be heard on the loudspeaker nor recorded by the graphic recorder. The protective and alarm relay system is energized. When you want to listen to or record the signal from one or more shore

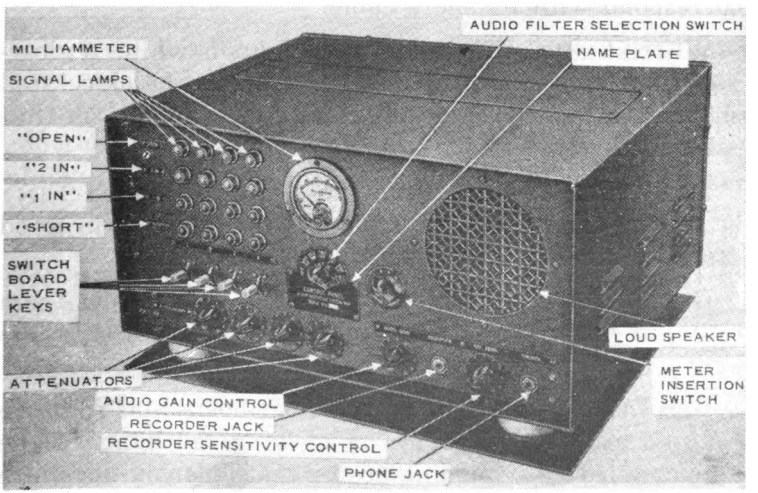

Figure 16–6.—Control panel.

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cables, depress the key for the cable(s). Return the key to normal and you remove the signal from the loudspeaker or headphones and from the recorder. If you depress two or more keys, the sound you hear will be a mixture of signals from two or more cables. Placing any key in normal or depressed position operates the protective and alarm relay system for that shore cable circuit. One of the lights in the column above the key will glow, indicating circuit conditions of the particular shore cable.

When you raise a key from the normal position, you open the shore cable circuit and the circuit to the associated relays and signal lights of the protective and alarm relay system. A dummy load of 1600 ohms is cut in automatically by the protective and alarm relays to protect the equipment from excessive voltages.

Signal Lights

The signal lights are arranged in four horizontal rows, each row a different color. As you can see in figure 16–6, these rows are labeled (reading down) : OPEN, 2 IN, 1 IN, and SHORT. Each vertical row of lights is numbered to correspond with its shore cable.

WHITE LIGHT.—The top row of lights is white. A glowing white light indicates an open exists in the associated shore cable. In other words, neither hydrophone on that cable is functioning.

AMBER LIGHT.—The next row of lights (labeled 2 IN) is amber. These lights glow when the cable is in good condition and both hydrophones are functioning.

GREEN LIGHT.—Lights labeled 1 IN (third row from top) are green. A glowing light here indicates only one hydrophone of the shore cable is functioning.

RED LIGHT.—Lights in the bottom horizontal row are red and are labeled SHORT. A glowing red light will be accompanied by a warning buzzer that tells you the shore cable circuit is grounded. When this happens, lift the key

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lever for that cable to the fully raised position. This shuts off the buzzer, allowing undisturbed operation of the remainder of the system.

Audio Filter Selection

The audio filter selection switch is a 7-position rotary switch located at the center of the control panel. The switch is labeled (clockwise):

OFF	300 HP	1KC HP	3KC HP	1KC LP	3KC LP	and 1KC 3KC BP

In the off position, the switch simply bypasses the filters. Other settings are 300 cycle, 1 kc and 3 kc high pass; 1 kc and 3 kc low pass; and a band pass of 1 kc to 3 kc.

Always operate the audio filter selection switch in the off position unless marine life noises are interfering. In that case, use the filter channel that most effectively eliminates the interference.

Audio Gain Control

You will use the attenuators to balance the background noises of the four shore cables, and you will control loudspeaker volume with the audio gain control. The gain control also affects the graphic recorder and the earphones. When you plug in the phones, the loudspeaker automatically is cut out. The audio gain potentiometer governs the input to the second stage of the audio amplifier and therefore controls the signal level at both the loudspeaker and recorder. Another control, the recorder sensitivity potentiometer, attenuates the signal to the recorder only, and thus allows you to regulate the sweep of the recorder pen without changing loudspeaker volume.

The meter insertion switch has four positions, one for each shore cable circuit. Current readings for each cable are taken by setting the switch to the cable number and

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reading the milliammeter. The milliammeter should indicate between 90 and 100 milliamperes for shore cable circuits showing an amber light (2 IN), and between 45 and 50 milliamperes for circuits showing a green light (1 IN).

GRAPHIC RECORDER

The Mk 6 Mod 0 acoustic system measures small quantities of sound which it converts to electrical energy. The graphic recorder shown in figure 16–7 presents this information to you as a signature. Connection to the control panel is made by plugging the recorder into a jack. By depressing the switchboard lever keys, you can record the signal from a particular shore cable or, by depressing more than one key, you can record the simultaneous output of a combination of the four shore cables.. When a

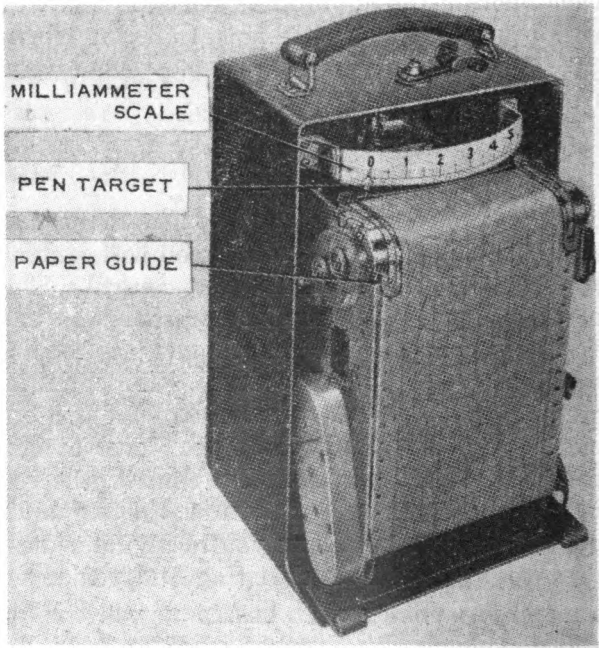

Figure 16–7.—Graphic recorder with cover removed.

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ship passes over a hydrophone, the record of its signal is an acoustic signature of the vessel.

Movement of a milliammeter causes a pen to trace a signature on the recorder paper. As a vessel nears the hydrophones, the intensity of the signal increases, reaching maximum when the stern of the vessel is directly over the hydrophones. The milliammeter responds to these changes in output of the audio amplifier, causing the pen to sweep horizontally across a graduated chart. Since the chart is driven at a constant speed, the result is an acoustic signature of the vessel.

Milliammeter

The graphic recorder milliammeter is a permanent magnet, moving-coil type. It has a full-scale deflection of 5 milliamperes and an internal resistance of either 65 ohms or 400 ohms, depending on the model. The meter is coupled to a glass pen, free to move across the recorder chart in response to signals from the hydrophone preamplifiers. A red target, mounted on the pen arm, moves with the pen to indicate signal amplitude on a scale graduated from 0 to 5 milliamperes.

Control Lever

You can start or stop the spring drive of the chart by moving the control lever to either the START or STOP position. A third position of the control lever, marked RAPID FEED, increases chart speed sixtyfold and thus changes chart speed from so many inches PER HOUR to the same number of inches PER MINUTE. Increased chart speed magnifies the signal and makes it easier for you to read the signature.

Different combinations of change gears on the chart drive mechanism produce various chart speeds. When issued, the recorder comes with a pair of gears that produce a chart speed of 12 inches per hour with the control lever in its START position. Other gear combinations pro-

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duce the following chart speeds (in inches per hour) : ¾, 1½, 3, 6, and 12. Of course, shifting to RAPID FEED converts each speed to inches per minute.

Winding Crank

Two heavy springs drive the clock movement operating the chart drive roll. A separate spring rotates the chart reroll. All three springs are located in the spring barrel and are wound simultaneously with a winding crank. The reroll spring is arranged so that it becomes fully wound before the driving springs are completely wound; a slipping clutch allows complete winding of the driving springs. When the clutch slips, the crank doesn't turn smoothly. This is normal, so don't mistake it for equipment failure.

Rewind the chart drive mechanism every 7 days. This requires 108 turns of the crank. The mechanism will operate at standard speed for 8 days and will require between 175 to 185 turns to rewind, if allowed to run down completely. Although the chart drive springs must be wound until the crank refuses to turn, THE CRANK MUST NOT BE FORCED otherwise you will damage the springs by overwinding.

You can determine quickly whether the chart drive mechanism is functioning by sighting a white target visible through a small window in the recorder. When the escapement is running, the white target moves up and down.

Complete details for installation and maintenance of the Mk 6 acoustic system are contained in a Bureau of Ordnance publication, OP 1854, titled *Acoustic System Mk 6 Mod 0.*

THE HERALD

The HERALD is an echo-ranging and listening device planted on the bottom of harbors and bays. Like searchlight sonar aboard ship, it gets ranges and bearings on

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undersea targets, transmitting the information by cable to the detection station ashore. The echo ranging is controlled by a harbor defense Sonarman operating his console in the detection station.

Everything you learned about doppler, bearing movement, the behavior of sound in water, the bathythermograph, etc., applies to the operation of the herald.

WATER STATION UNIT

That part of the herald which is located at the bottom of the harbor is a tripod structure called the WATER STATION UNIT. (See fig. 16–8.) The unit contains a Rochelle salt transducer which echo ranges on frequencies from 10 to 50 kilocycles. The principle of echo ranging here is exactly the same as aboard an anti-submarine vessel. The transmitter keys the transducer which sends a pulse into the water. The transducer then listens for returning echoes.

Because of its size and weight, the herald transducer does not move in azimuth. The training of the sound beam is accomplished by an ACOUSTIC MIRROR located beneath the transducer. The transducer sends out its pulse

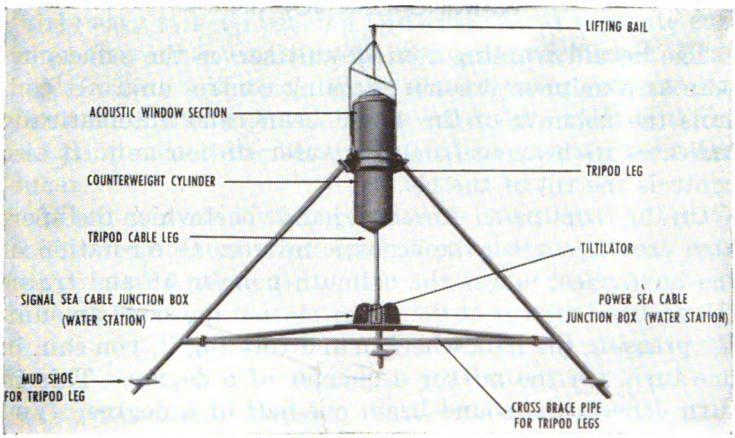

Figure 16–8.—The herald water station unit.

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and the mirror deflects it in much the same way as a mirror will deflect a beam of light. The operator on the beach can train the mirror just as a shipboard Sonarman trains a searchlight sonar transducer.

The mirror can also be tilted from 0 to 10 ACOUSTICAL degrees above the horizontal. The actual tilting is limited to a vertical arc of 0° to 5°, but an acoustical degree is double a regular degree. The mirror is an oval-shaped steel plate 25 inches across at its greatest diameter and 18 inches at the smallest. The incoming sound wave is received by the mirror and reflected upward to the transducer. When a transmission is sent from the transducer, the process is reversed.

Tiltilator

The tiltilator, which is a part of the water station, is a cylindrical housing filled with castor oil. Inside is a pendulum switch that makes contact when the herald tripod tilts as much as 14° due to the shifting of the ocean bottom. The pendulum switch closes a circuit which causes an alarm to sound in the detection station.

TRAINING CONTROL UNIT

The herald training control unit serves the same purpose as a shipboard sonor training control unit. It controls the azimuth of the sound beam, and automatically indicates its bearing from the water station unit. It also controls the tilt of the beam.

On the front panel there is a handwheel which the operator uses to control the acoustic mirror. One rotation of the handwheel moves the azimuth pointer 5° and trains the acoustic mirror at the water station the same amount. By pressing the handwheel in and rotating it, you can, in one turn, tilt the mirror a quarter of a degree. This in turn deflects the sound beam one-half of a degree. You have a tilt dial which tells you how much the beam is deflected from the horizontal.

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The receiver functions on the same principle as a conventional sonar receiver. Ranges are read from a horizontal scale marked on the lower side 0 to 1000 yards and, on the upper side, 0 to 4000 yards. Read the ranges according to the range selector switch setting.

SHORT-PULSE RECORDER

The tactical range recorder you studied in chapter 8 (CAN 55134A) has been modified for short-pulse operation in harbor defense. As a short-pulse recorder it has a range of 600 yards and is used mainly for detection of small sneak craft.

The herald has been modified by addition of a training control unit that sends bearing traces to the recorder. Thus the operator reads both bearings AND ranges from his recorder. One scale on the recorder provides range (0 to 600 yards) and the other supplies bearings. When you have an underwater contact, you will work with two sets of traces. There need be no confusion since you will control the recorder bearing marker by training the handwheel on the sonar console. A rotating switch closes to print the bearing contact. The point at which the switch closes is governed by the training wheel. It is fairly easy to keep bearing and echo traces separate even when they cross, as they will with a closing target. Bearing markers will stack up on the recorder ONLY IF YOU REMAIN ON ONE BEARING. Otherwise, they shift to different points along the bearing scale as you train the transducer.

When you shift the recorder to STANDBY, the herald shifts from short-pulse operation to conventional long-range search sonar.

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QUIZ

1. According to tests, what is the best listening period for hydrophone operation?
2. Why is it likely that a submariner will select rough weather to attempt an entry into a harbor?
3. What is the purpose of a herald acoustic mirror?
4. In a herald installation, what is the water station unit?
5. How many Mk 5 hydrophones does one oscilloscope panel control?
6. The Mk 6 Mod 0 acoustic system is planted ahead of what units in harbor defense.
7. The attenuators on the control panel Mk 6 Mod 0 control what portion of the circuits?
8. The switchboard lever keys have how many positions?
9. What is the purpose of the graphic recorder?
10. What is the purpose of the short-pulse recorder?
11. What ranges does the short-pulse recorder provide?
12. How are the bearing markers controlled?

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CHAPTER 17

SONOBUOY

RADIO AND SONAR

The SONO RADIO BUOY, as the name suggests, is a device which picks up underwater sounds (SONO), transmits them to a control station by RADIO, and floats on the surface of the ocean as a BUOY. For the sake of brevity, the word "radio" is generally dropped and the equipment is known as a SONOBUOY. In permanent installations, such as our large stateside ports, sonobuoys are rarely used in harbor defense. They are particularly suitable for rapid installation at advance bases and as an underwater detection line about a newly secured beachhead.

The sonobuoy detects underwater sounds produced by moving power-driven watercraft, and transmits these to a shoreside listening station as a warning that a moving craft is present in the waters within range of the buoy. Under normal conditions a sonobuoy can detect the presence of a vessel underway at ranges of approximately 1500 to 2000 yards. The buoys are planted at the entrance of a harbor or area to be protected, and serve notice whenever a vessel is present in the area. The spacing of the buoys is set at 1000 yards to assure satisfactory coverage when water conditions are unsatisfactory.

A receiver to pick up the signal from the buoy is located on shore. It is continually tuned either manually or auto-

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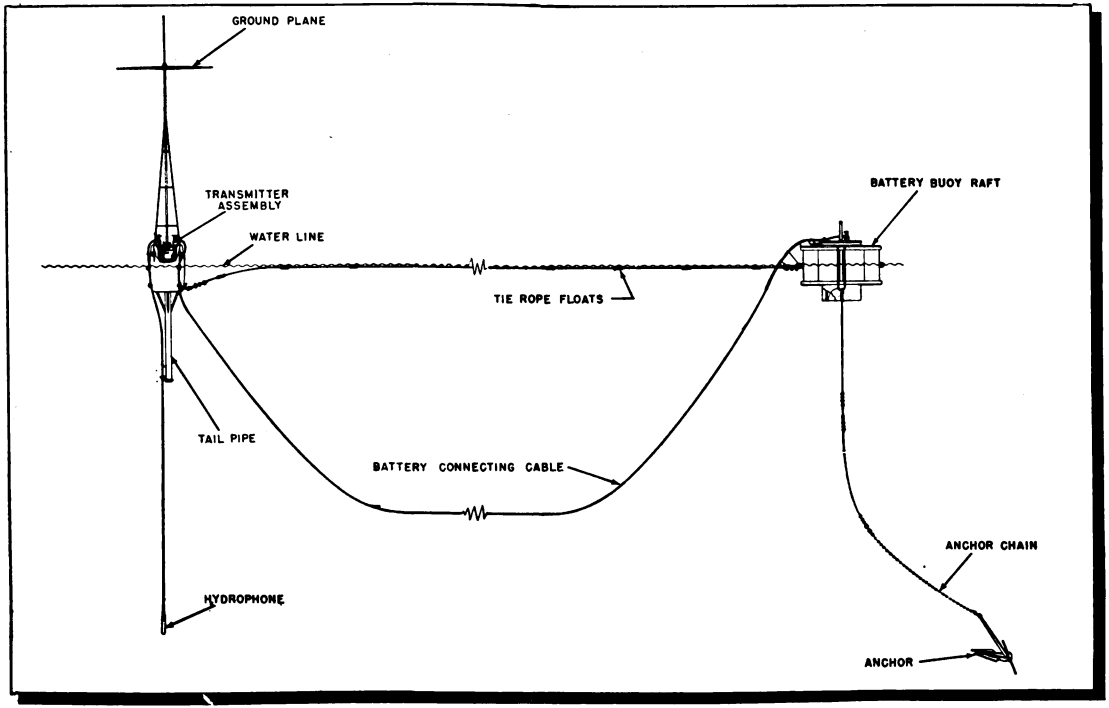

Figure 17–1.—Sonobuoy installation.

matically, so that each buoy is listened to at least once each minute. When a ship or sub is detected by a particular buoy, this buoy is selected for continued listening to verify the presence of the vessel. Should the sound be heard on more than one buoy, the loudest is assumed to be the closest to the vessel.

THE INSTALLATION

A typical sonobuoy installation is shown in figure 17–1. It consists of an FM transmitter and antenna, a large dry cell battery, and a hydrophone suspended in the water. Sounds enter through the hydrophone and are launched into the air by the transmitter which is powered by the dry cell battery.

When in operation, the equipment is arranged as follows: There is a floating battery raft to which the transmitter buoy is fastened by a length of cable. The cable which anchors the entire sonobuoy installation is fastened to the battery raft. The battery raft is only a source of power. The pickup and transmission of sounds takes place at the transmitter buoy from which the hydrophone is suspended, and on which the antenna is mounted.

Transmitter Buoy

The transmitter buoy is made of a 53-gallon steel barrel. The transmitter itself is located on the bottom side of the buoy cover where it can be removed simply by taking off the buoy cover. It operates at any frequency in the range from 70 to 90 megacycles and signals can be picked up at distances of 10 miles or more.

Tuning controls and volume control for the transmitter unit are located on the top surface of the buoy cover. Dial calibrations can be seen through a plastic-covered opening in the cover near each control. A hinged cover protects the controls from damage. See figure 17–2.

The telescopic, vertical antenna has stamped calibrations for the frequency range of the equipment. Mounted

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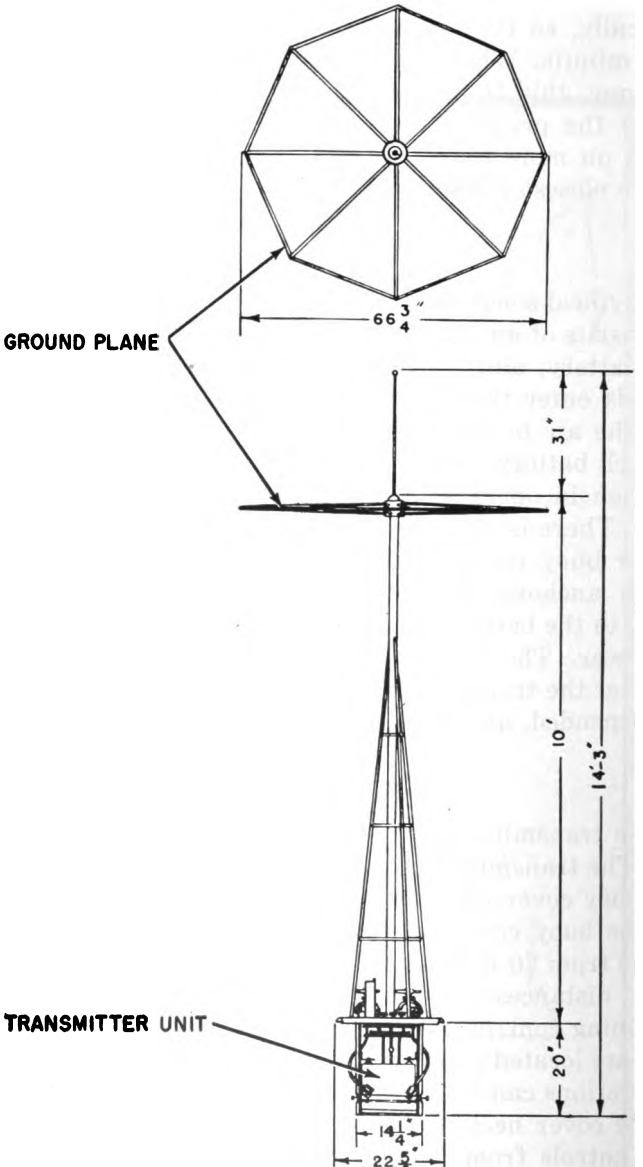

Figure 17–2.—Antenna assembly.

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near the top of the antenna is an octagonal metal wheel called the ARTIFICIAL GROUND PLANE. The purpose of the ground plane is to produce a horizontal sheet of good conductivity, which helps to ensure a good signal. See figure 17–3.

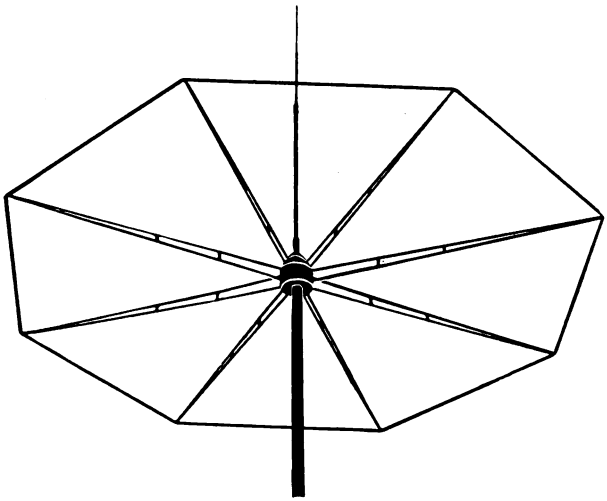

Figure 17–3.—Artificial ground plane.

Beneath the buoy there is an extension called the tailpipe. It is weighted at the bottom end to keep the buoy upright, and can be removed for easier handling and stowage of the equipment.

A standard tire valve is installed on the buoy cover, through which air can be pumped into the transmitter buoy to test it for leaks. See figure 17–4.

Beneath the buoy, attached by a 60-foot length of cable, is the hydrophone. The sound-sensitive elements of the hydrophone are two identical Rochelle salt crystals. They are mounted in a metal framework which also supports a transformer. The entire hydrophone assembly is covered with a watertight, sound-transparent, rubber sleeve which is filled with castor oil.

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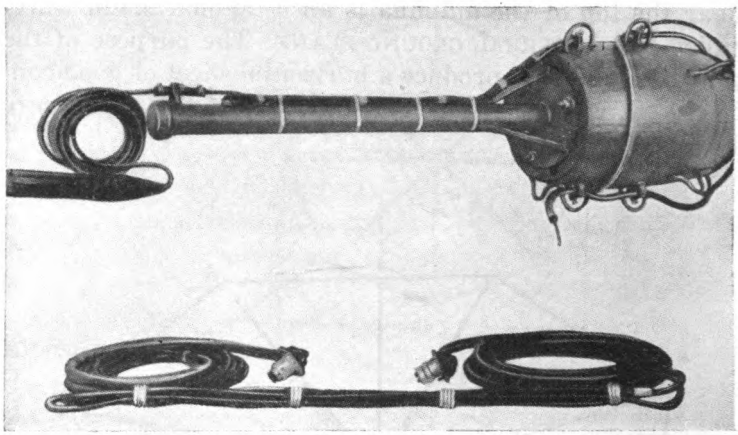

Figure 17–4.—Transmitter buoy, tailpipe, and hydrophone.

Because high temperature will damage the crystals, the hydrophone should always be kept out of heat or direct sunlight. When you stow it, be sure it's carefully packed and kept in a cool place. It should at no time be subjected to temperatures above 120° F. Before putting it in service, carefully wash it with soap and water to remove all dirt, oil, and grease.

Battery Buoy

The battery buoy is made of eight watertight steel drums secured to a steel framework. The framework has a becket on one side for securing the tie rope which connects the battery buoy to the transmitter buoy. There is a circular opening at the center of the buoy in which the battery container is placed. The buoyancy of the battery buoy will support the battery, its container, and at least 300 pounds of anchor line. See figure 17–5.

A 200-pound Danforth anchor is provided by which the sonobuoy is anchored in place until permanent concrete block anchors can be made. The concrete blocks, which are constructed as needed, weigh from 2000 to 5000 pounds in air.

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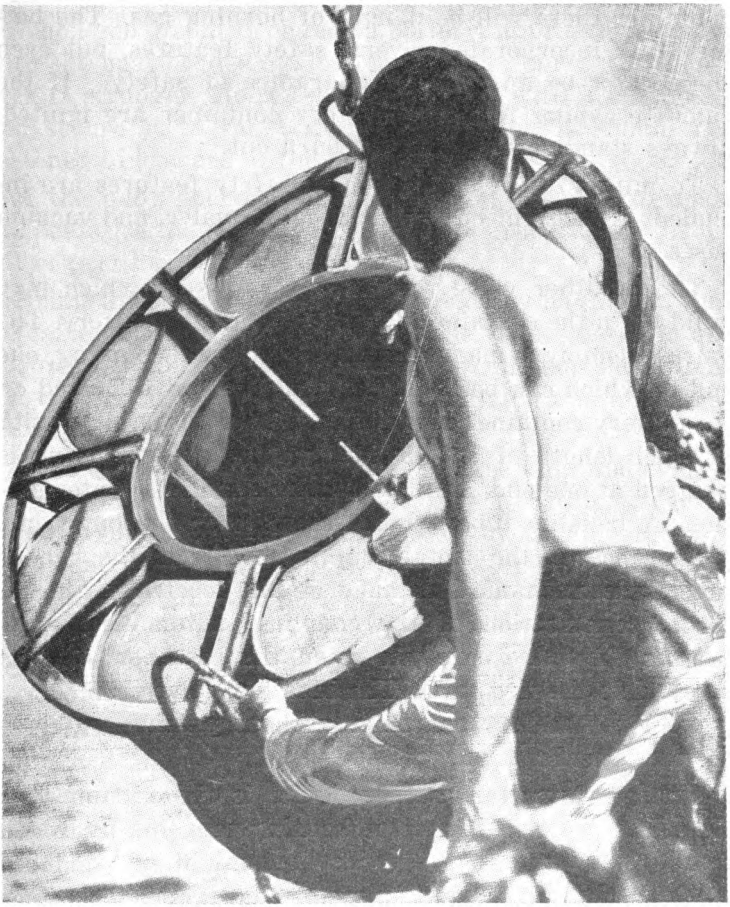

Figure 17–5.—Installing a battery buoy.

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The numerous dry cells in the battery, like all other standard dry cells, give off small quantities of hydrogen. If the hydrogen is allowed to accumulate inside the sealed container there will be danger of burning gas. The battery raft incorporates several safety features, but even these can't be an absolute guarantee of safety. If the fumes escaping from the battery container are ignited, always stand clear until they burn out.

To minimize the danger, these safety features are included: A gastight housing, a breather valve, and vacuum fuses.

The breather valve releases any pressure which may build up in the container due to gas from the battery. The valve assembly is made of a machined metal coupling, one end of which can be screwed to the tire valve located on the battery container cover; the other end is covered with a 2-inch length of rubber tubing. The rubber tubing is plugged at one end, and has a razor slit in its center section. A bakelite tube, which screws over the outer circumference of the metal coupling, protects the rubber tube from mechanical damage. A pin, located in the internal construction of the coupling, automatically depresses the valve core pin when the breather valve is screwed to the tire valve. The breather valve then serves to vent the battery container without passing water in the opposite direction.

Another important safety device is the vacuum-type fuse. The gastight connector housing prevents hydrogen from being exposed to sparks that might be produced when the battery cable is disconnected from the battery container. The vacuum-type fuse assembly is a part of this connector housing. Using vacuum-type fuses greatly reduces the possibility of a blowing fuse igniting the accumulated hydrogen inside the container. Remember this: NEVER USE FUSES OTHER THAN THE VACUUM-TYPE.

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CHANGING BATTERIES

The battery is designed to operate the transmitter for a continuous period of approximately 3 weeks. After that it should be replaced with a fresh battery.

When you go out to change a battery, approach the raft with the boat headed against the wind or current, whichever is stronger. Hook the battery raft with a boathook and secure it to the boat near the bow. It should be fastened to leeward of the boat.

If the buoy anchor tackle isn't strong enough to hold the boat, use the engines to keep from dragging the buoy out of position.

Bring the transmitter buoy alongside by hauling in the tie cable and battery-connecting cable. This gives you an opportunity to inspect the condition of these cables. Turn the transmitter off. Open the battery latch and hoist the battery container on deck.

When you turn the transmitter off, keep in mind everything you know about sonobuoy safety precautions. First, be sure you turn the transmitter off by turning the a-f GAIN control counterclockwise to the OFF position. Do this BEFORE REMOVING the power plug from the battery container. Keep all flames and sparks away from the battery container during disconnection and opening. Release all pressure in the battery container by opening the container cover before disconnecting the connectors. Always keep your head and body clear of the area immediately above the battery container cover.

You should wipe the connector on the battery container reasonably dry and remove it from the watertight housing. Next, secure it to the fresh battery and clamp it in place with the cable clamp. Then lower the battery into the container and close the battery latch.

To make sure the transmitter is sending out a signal, it should be tuned in by a receiver in the boat, or one on shore. Once this is done, and the buoy is operating satis-

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factorily, release the transmitter buoy and let it drift free of the boat. Next release the battery buoy raft and anchor line.

RETRIEVING THE EQUIPMENT

To retrieve sonobuoy equipment you follow almost the same procedure as you do when changing a battery. After the transmitter buoy has been secured alongside, remove the antenna spike and the ground plane. Hoist the transmitter buoy to the deck and remove the tailpipe, the hydrophone, and the battery cable connector. Raise the battery container, the battery buoy raft, the anchor line, and the anchor. In handling the battery container ALWAYS OBSERVE THE SAFETY PRECAUTIONS.

SONIC LISTENING

As a sonic listening device, the sonobuoy is extremely sensitive. An experienced operator can distinguish one type of submarine from another; he can identify the type of surface ship to which he is listening, and even recognize the type of propulsion. Under good sound conditions a sub proceeding at high speed on diesels has been heard as far as 10 miles.

It takes careful training and plenty of practice to identify correctly and instantly the sounds you hear on the sonobuoy receiver. This book can tell you what you can EXPECT to hear, but it will take practice on the equipment and careful listening to recordings of underwater sounds to identify what you DO hear.

To be a good harbor defense Sonarman you must know the sounds that come from your harbor as well as you know the sounds in a familiar room. When you evaluate a sonic contact you should be able to tell whether it's a noisy ship many miles away or a quiet ship near at hand. Here's one way of telling: A sonic contact with a high-speed target at a range of 10 miles will be weak and made up of propeller sounds only. At 2 miles or less, a contact with

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the same target will be composed of both propeller and machinery sounds. The received signals will be very loud.

A sharp operator can judge the position of his target from the sounds he hears. He knows, for instance, that water conditions are apt to be unusually good at night. For a given noise level, he knows that a target at night is farther from the buoy than one he picks up by day. The propeller beat is another tipoff on the location of a target. When the propeller sounds indicate a slowly moving submarine, it's safe to assume that the sub isn't very far from the buoy which is picking up the signal. A faster propeller beat with signals that are weak in intensity generally indicates the sub is a considerable distance away.

You will be able to hear a submarine's propellers because they are turning fast enough to produce CAVITATION. You won't be able to hear slow-moving props, because there is no cavitation. In that case, you may detect other sounds: The main motor hum, reduction gears, and machinery sounds such as those made while the diving-plane angle is being changed. If the sub is forced to use ballast pumps or blow tanks, you can hear the sound. However, none of these will be very loud. It's up to you to be constantly alert for the slightest sign of unusual noises coming from your listening system.

As a general rule, you won't have more than seven sonobuoys to scan. Since you have to listen to each buoy individually, the principle of the listening search is similar to echo ranging with searchlight sonar. In sonar you searched in 5° steps, thus covering the area about your ship without leaving gaps for subs to slip through. The same applies when you cut in sonobuoys. If you took 20 seconds to listen to each one, it would require more than 2 minutes to check all seven buoys. With the buoys spaced at 1000 yards, you are checking a frontal distance of about 3 miles.

A very quiet submarine creates sounds which can't be picked up at range over 500 yards. It would therefore be

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possible for a submarine moving at a speed of about 2½ knots (or below cavitation speed) to pass through the sound screen at one place while you listened to a buoy at another point.

As an added margin of safety, it's standard practice for an operator to be responsible for not more than five buoys during a sound watch. Furthermore, during a normal search a maximum of only 10 seconds is spent listening to each buoy.

DOPPLER

Doppler is important in sonic listening just as it is in ultrasonic echo ranging. Doppler will help you distinguish between a moving and a stationary target. It will also help you determine whether the target is going toward or away from your listening gear.

It's done in this way: You simply compare the pitch of the sound at two or more listening points. If the pitch is higher on one than the other, the target has a component of movement toward the listening station giving the higher pitch. You have no positive way of determining the target's speed, but if you can identify the vessel—ship or submarine—you can count the propeller revolutions per minute and figure out the approximate speed. So, by intelligent use of your equipment you can identify the type of vessel and get an approximation of its course (by doppler) and speed (propeller beat).

Because a long sonic watch will tire the operator's ears, most watches are limited to 30 minutes, and never exceed 1 hour. After that you will rotate to some other position—radar, plot, or the telephone watch. Regardless of whether you are on the radar or manning sonic listening equipment ALWAYS REPORT IMMEDIATELY anything unusual that you hear or see while manning the gear. It's far better to be in error on the safe side than to hesitate in reporting a live target.

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ICING

The sonobuoy is designed to withstand strong currents and rough seas, but even so it can be put out of action by the weather. Operators in harbor detection stations have found that the buoys sometimes behave erratically in cold weather. The equipment operates normally during daylight hours but at night the buoys, one by one, mysteriously leave the air. A check of the buoy line shows that ice has formed on the antenna and ground plane, causing the transmitter buoy to lay on its side. This grounds the antenna, preventing transmission of signals. See figure 17–6.

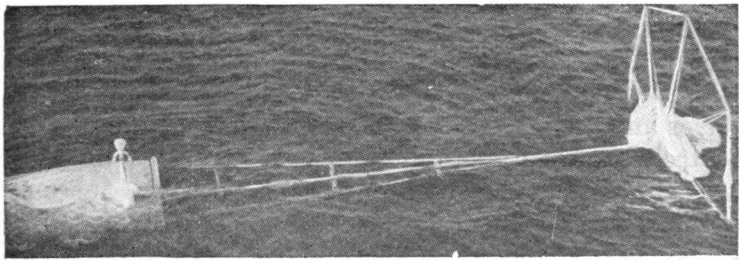

Figure 17–6.—Icing.

Considerable damage can be done to a buoy by heavy icing, but there is little that you can do about it. In colder climates cable-connected hydrophones are used to replace sonobuoys in the listening line.

RECEIVERS

There are two types of special receivers used to pick up transmissions from radio sonobuoys. One consists of a rack and panel assembly of 10 receiver units with a common power supply and a switching unit. Each receiver is tuned to a particular buoy and the switching unit automatically connects the different receivers to a common amplifier system.

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Because this type is a relatively heavy installation which requires considerable power (600 watts), it is generally used only at well-established harbor defense stations.

The second type has but a single receiver and a mechanical tuner. The mechanical tuner brings in each sonobuoy and thus gets the same results as the heavier unit with its 10 receivers. This type is small, compact, and considerably more portable than the 10-receiver equipment. You can tune the buoys in by pushbutton, or set the equipment for automatic tuning. The controls of this receiver are explained below.

Receiver Controls

To operate a sonobuoy radio receiver you must be familiar with the controls, their function, and position. Figures 17–7 and 17–8 show you the front panel of the radio receiver and the radio tuner unit. Study the positions of the controls shown in these illustrations.

The POWER switch, used to turn the radio receiver off or on, is located near the right side of the front panel. At

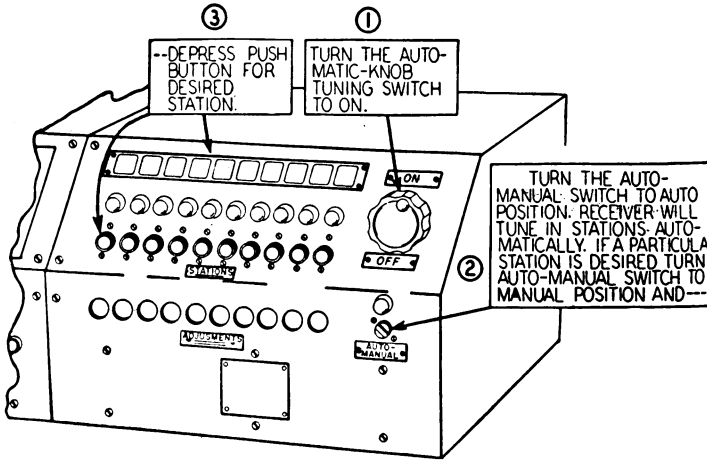
③
①
--DEPRESS PUSH BUTTON FOR DESIRED STATION.
TURN THE AUTO-MATIC-KNOB TUNING SWITCH TO ON.
ON
OFF
STATIONS
ADJUSTMENTS
AUTO-MANUAL
②
TURN THE AUTO-MANUAL SWITCH TO AUTO POSITION. RECEIVER WILL TUNE IN STATIONS AUTO-MATICALLY. IF A PARTICULAR STATION IS DESIRED TURN AUTO-MANUAL SWITCH TO MANUAL POSITION AND---

Figure 17–7.—Front panel, radio receiver.

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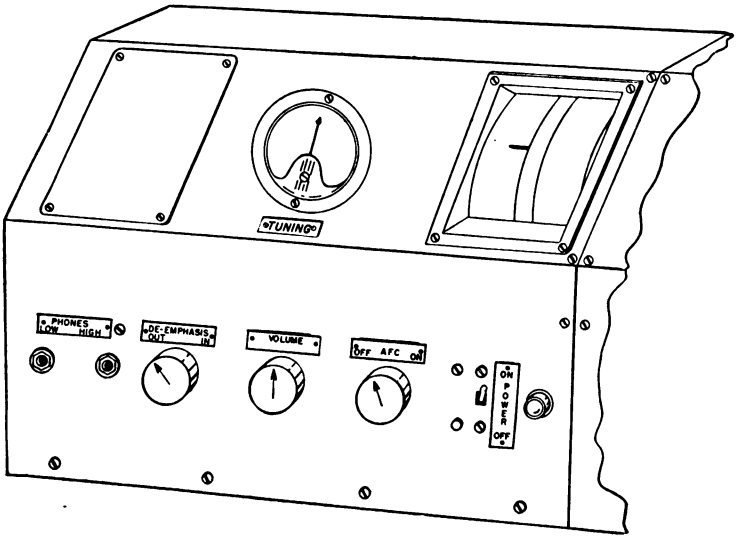

Figure 17–8.—Front panel, radio tuner unit.

the right of the switch, mounted behind a blue jewel, is a pilot light which indicates when the receiver is turned on.

The DE-EMPHASIS control is located at the left of the receiver front panel. The function of this control is similar to that of a tone control on a broadcast receiver. The control has seven positions. When the arrow on the knob points to the left, the control is OUT. As the control is turned clockwise, the attenuation of the high frequencies will be increased at each position.

The VOLUME control is located at the center of the panel. As you rotate the knob to the right (clockwise) the audio output increases.

The OFF-AFC-ON switch turns the automatic frequency control circuit off or on. In the ON position, the automatic frequency control circuit causes the frequency of the oscillator signal to shift automatically. This shift compensates for inaccuracies due to the setting of the tuning control on the receiver to the buoy transmitter's drift in frequency.

There are two phone jacks available. The one on the left

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is for use with low-impedance or dynamic-type headphones having an impedance of 50 ohms. The phone jack on the right is for use with high-impedance, crystal-type headphones.

TUNING

The tuning knob is located on the right end of the cabinet. With this control, the receiver may be tuned manually to any desired frequency in the 70–90 mc band. It allows tuning between the frequencies set up on the automatic tuner.

The tuning knob must turn freely on its shaft when it is not used for tuning. Whenever the receiver is to be tuned with the tuning knob, the small knurled metal locking nut must first be tightened until the large tuning knob is locked securely to the shaft.

Before attempting to tune the receiver either automatically or manually with the pushbuttons, the small knurled metal locking nut must be loosened until the tuning knob will turn freely on its shaft.

Tuning Meter

The tuning meter, located on the sloping portion of the radio receiver front panel, is used when tuning the receiver with the tuning knob or when setting up the pushbuttons on the radio tuner unit.

The meter normally indicates zero. As the receiver is tuned across a station, the tuning meter pointer deflects either to the right or to the left, returns to zero, deflects to the opposite side of the meter, and finally returns to zero as the receiver is tuned away from the station.

The zero indication between the two deflections (referred to as the zero center position) occurs when the receiver is accurately tuned to the station frequency.

When tuning in a station, you may differentiate between the zero center position and the normal zero indication of the meter as follows:

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Detune the receiver slightly in either direction from the supposed zero center position. The tuning meter pointer should deflect toward one side of the meter. Detune the receiver slightly to the other side of the supposed zero center position. The tuning meter pointer should swing to the opposite side of the meter.

If the receiver was not properly tuned to the zero center position, there will either be only one deflection of the tuning meter or both deflections will be to the same side of the meter scale when the receiver is detuned from the supposed zero center.

It may not be possible to obtain a definite deflection to each side of the zero center position with the OFF-AFC-ON control turned ON.

Meter Switch

The meter switch is located on the chassis near the first limiter tube. The control has two positions, TUNE and ALIGN. When you want to use the meter on the front panel as a tuning indicator, the meter switch must be turned to TUNE. If the meter is to be used as an indicator for aligning the receiver, turn the meter switch to ALIGN.

Automatic-Knob Tuning

This control, when turned to the left, disconnects the radio tuner unit from the a-c power supply and allows the receiver to be tuned with the tuning knob located at the right end of the cabinet. When the control is turned clockwise, the a-c power is turned on. The receiver may then be tuned either automatically or manually with the pushbuttons. Near the outer edge of the control is a detent pin. When the control is turned either to the right or left, it must be turned until the detent pin slips into a stop and positions the control correctly.

Auto-Manual

When this control is turned to the AUTO position, the radio tuner unit will tune automatically each of the sta-

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tions that have been previously selected. With the control in the MANUAL position, you may tune the receiver by means of the pushbuttons to the desired station.

Pushbuttons

Ten pushbuttons are located on the sloping portion of the radio tuner unit front panel. Above each pushbutton is a sonobuoy station indicator light that glows when the pushbutton has tuned in a sonobuoy station. The pushbuttons may be individually operated in whatever sequence you choose.

QUIZ

1. What is the purpose of the artificial ground plane?
2. What is the transmission range of a sonobuoy?
3. Give the frequency span used by a standard moored sonobuoy.
4. Name the three safety features included in the battery raft.
5. What added safety is provided by vacuum-type fuses?
6. How is doppler indicated in sonic listening?
7. What two methods of tuning are afforded by the latest type sonobuoy receiver?

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APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

THE SONARMAN

1. The Sonarman emergency service ratings are Sonarman G (SOG) and Sonarman H (SOH).
2. Sonarmen in submarines or aviation hold general service ratings.
3. Professional qualifications for advancement in rating are divided into practical factors and examination subjects.
4. NavPers 10052 provides the student with sources of study to prepare for examination, and serves the examiner as a guide to source material for examination items.
5. Ratings in the deck group are SO, RD, BM, and QM.
6. A rate is a step within a rating. It is also a pay grade.
7. Sonar is a means of underwater detection. Antisubmarine warfare is the entire process of detecting, tracking and sinking submarines. It includes control of weapons for destroying the target.
8. A Chief Sonarman can be promoted to a Warrant Electronics Technician.

CHAPTER 2

SUBMARINES AND SONAR

1. David Bushnell.
2. (a) The Dutch. (b) The Germans in World War II.
3. Torpedo.
4. Echo ranging and listening.
5. The sonar console or stack.

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6. By adjusting the length of the electronic cursor to echo pip and by reading range dial.
7. It scans 360° at each transmission and gives a visual presentation of the results.
8. They will indicate the launching time of A/S weapons.
9. Hedgehogs, depth charges, and torpedoes.
10. They explode only on contact, are fired before ship passes over contact, and there is no underwater disturbance unless a hit is made on the submarine.
11. Twenty-four charges.
12. The Mk 15 provides full gun train.
13. They detonate on contact.
14. Hydrostatically.
15. Influence type.
16. Weapon A.
17. Twelve per minute.

CHAPTER 3

BEARINGS AND MOTION

1. True bearing is the direction of the target measured in degrees from true north.
2. (a) 096. (b) 278. (c) 285. (d) 090.
3. (a) 217 (b) 081. (c) 100. (d) 359.
4. (a) 109. (b) 114. (c) 041. (d) 311.
5. (a) 000. (b) 135. (c) 315. (d) 270.
6. The contact bearing would be about 315° R. Then it would be 000° R as the ship heads for the target. Then it would move right, to perhaps 010° R. When the lead was applied, it would move left to about 340° R. As the ship passes ahead of the submarine, it would fall down the port side.
7. The cursor indicates the true bearing to which the audio scanning switch of your equipment is responding.
8. First indication of gyro failure will be the lighting of the red GYRO OFF light.

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CHAPTER 4

UNDERWATER SOUND

1. (a) High marked.
   (b) No doppler.
   (c) No doppler.
   (d) Low moderate.

2. (a) No doppler.
   (b) Low moderate.
   (c) High slight.
   (d) No doppler.

3. (a) No doppler to low slight to low moderate.
   (b) High slight to high moderate to high marked.
   (c) No doppler to high slight to high moderate to high marked.
   (d) No doppler.

4. (a) 200°, 6 knots.
   (b) 210°, 4 knots.
   (c) 135°, 4 knots.
   (d) 140°, 6 knots.

5. (a) Up.
   (b) Down.
   (c) Up (due to pressure).
   (d) Up (due to pressure).

6. Reducing gain reduces the amount of unwanted signals.

7. Salinity, pressure, and temperature are three factors influencing the speed of sound through water.

8. Scattering is caused by foreign matter such as air bubbles, animal life, seaweed, and silt.

9. (a) .25 foot (b) .35 foot (c) .44 foot (d) .6 foot.

10. Hydrophone effect is the noise generated by ship's propellers, auxiliary motors, fans, etc.

11. Both increasing temperature and increasing pressure tend to increase the speed of sound through water.

12. Skip distance is the bouncing of a sound beam between ocean floor and ocean surface. It is likely to occur only in shallow waters.

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CHAPTER 5

THE BATHYTHERMOGRAPH

1. The trace scratched by the stylus is a temperature-depth curve. Each point on the trace represents the temperature at a given depth.
2. BT readings should be taken in the morning, early afternoon, and late afternoon.
3. The speed of the ship is the factor which most affects the depth at which the BT rides.
4. The temperature is the same throughout.
5. The maximum safe temperature for the BT is 105° F.
6. If any part of the tube on the thermal assembly becomes inoperative, the trace will be a vertical straight line.
7. The 450-foot BT should be read to 0.1° F. and 5 feet.
8. The BT should be cleaned with grade III rust-preventive compound.
9. The BT measures the temperature at various depths. This makes possible the prediction of sonar contact ranges.
10. By taking a sample of sea water in a bucket and measuring the temperature with a thermometer. Also from the injection thermometer.
11. He must know so that he will not increase speed too much or turn the ship in such a way that the screws will cut the cable.
12. Cut the cable off inside the kink and attach the BT to the new part of cable.
13. By watching the angle the cable makes with the surface, or by watching the revolution counter.
14. To the Hydrographer, Hydrographic Office, Navy Department, Washington 25, D.C.
15. The OC–C/S series.
16. The OC–3B/S, OC–3C/S, commonly known as the deep BT.
17. The BT records temperature ranges from 28° to 90°.
18. There are 45 feet of copper tubing connected to the Bourdon tube assembly.
19. It is filled with liquid xylene.
20. The two principal inside assembly parts of the BT are the pressure element and the thermal assembly.

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CHAPTER 6

SONAR EQUIPMENT

1. Azimuth search sonar provides audio response and video display.
2. The three steps of underwater search process are transmission, reception, and presentation.
3. It amplifies and converts the video signal for presentation on the cathode-ray screen, and it amplifies and converts the audio signal to the proper level and frequency to drive a loudspeaker.
4. The three choices of pulse lengths are 6, 30 and 80 milliseconds.
5. Screw noises appear as wedges of light on the CRT.
6. Sixteen transducer staves are used to form an acoustic beam.
7. (a) There are 48 segments in the audio and video scanning switch of QHB equipment.
   (b) On the SQS–10 and –11, rotor and stator plates are divided into 144 segments to form three complete sectors of 48 segments each.
8. (a) Sonar target true bearing.
   (b) Sonar target relative bearing.
   (c) Own ship's course.
   (d) Increment of azimuth sonar train.
9. Three cursors available in AN/SQR equipment are: depression angle (*Eq*), depth (*Hq*), and listen.
10. AN/SQR transducers scan 240° at 100 scanning cycles per second.
11. To communicate using the hand key, the selector switch must be in the listening position.
12. Model QJB searchlight sonar has a crystal transducer.
13. Model QGA searchlight sonar has two transducers.
14. Three recorder ranges of AN/UQN–1B equipment are: 0 to 600 feet, 0 to 6000 feet, and 0 to 6000 fathoms.
15. After energizing AN/SQS–10 or –11 equipment you should wait 270 seconds, or about 4½ minutes.
16. Lighting of the XMTR THERMAL LIMIT indicator means that the transmitter is overloaded and its power output has been reduced automatically.

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CHAPTER 7

OPERATING THE CONSOLE

1. They appear as bright wedges on the sonarscope.
2. By bisecting the noise spoke with the audio cursor.
3. Train the audio cursor to the bearing of pip and investigate.
4. The MCC switch decreases the intensity of wake echoes and usually makes the echo stand out.
5. It reduces the size and width of echo pip and increases bearing accuracy.
6. No clearly defined reverberations are present with which to compare the pitch of the returning echo.
7. CIC controls the time and the entire search.
8. Relative bearing procedure.
9. A search is an organized plan for detecting a submarine.
10. Normally, the operator searches in 10° steps.
11. During the search, you PING—TRAIN—LISTEN. After contact you PING—LISTEN—TRAIN.
12. To investigate an arc, you train in 2.5° steps.
13. The proper way to report a contact is: "Sonar contact, bearing ....., range ....."
14. A cut is the bearing of the audio cursor or transducer when the sound beam first comes onto the target.
15. You should gage your steps so that you have three pings on the target and one ping off either end.
16. After reporting NO ECHOES the operator trains 20° aft of the last good bearing.
17. The deeper the submarine, the greater the range at which you can expect to lose contact.

CHAPTER 8

TACTICAL RANGE RECORDER

1. In simple terms, range rate is the speed at which you close the range on a target.
2. The information on the recorder chart constitutes a time-range plot.

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3. The three positions of the gear change lever are: Neutral, long-scale keying, and short-scale keying.

4. The sensitivity control governs the printing of the trace. The lower you turn it, the lighter the trace will be.

5. You shift to short scale when the range closes to 200 yards less than the maximum short-range scale.

6. With a 15-knot attack speed and the sub headed toward you at 3 knots, the range rate would be 18.

7. The correction is made on the firing lag scale.

8. When you zero-zero the recorder you place the pivot point at zero time and zero range.

9. The recorder must be on short scale before firing because all firing adjustments are designed for short-scale range.

10. On long-scale keying the flyback should be kept at 500 yards greater range than the echo.

11. R_E is the EFFECTIVE RANGE of throwing weapons.

CHAPTER 9

SONAR COMPUTER GROUP

1. Its primary function is to calculate and transmit the horizontal range of a sonar target.

2. (a) Sonar range. (b) Horizontal range. (c) Sonar depression. (d) Refracted sonar depression. (e) Relative target depth. (f) Transducer depth. (g) True target depth ($H'q + Pvq = Hq$). (h) Decrease of velocity of sound in thermocline.

3. Three: Range variable, full scale, and long scale.

4. The sonar computer-recorder group synchronizes the pulse transmission of both units.

5. A new roll of paper should be inserted in the recorder as only about 6 feet of paper remains.

6. Once daily in port and at the beginning of each watch at sea.

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CHAPTER 10

RECORDER TRACES

1. The five standard target inclinations are: Beam, quarter, bow, stern-on, and direct-bow.
2. Doppler and recorder traces work together. The recorder operator uses doppler as a check on the traces appearing on the chart.
3. Because some of the echo returns from the wake, some from the stern, some from the conning tower, and some from the bow.
4. One of the best ways to begin identifying a trace is to decide first if it is a beam trace.
5. If wake appears on a right cut-on, the target is moving left.
6. As a rule of thumb, line up the plotter bar, hence the range rate, on the right side of a quarter or stern-on trace.
7. Wake trace is characterized by no doppler, long individual echoes, and irregular waves and loops.
8. The range rate of a knuckle will always equal the attack speed of your ship.

CHAPTER 11

THE ATTACK PLOTTER

1. The cathode-ray tube is 12 inches in diameter and has 10 inches of usable surface.
2. The AP plotting scale is set so that 1 inch equals 250 yards.
3. The predictor line will remain at 0° relative.
4. The focusing control is located lower left, inside the AP.
5. The best time to reposition the plot is immediately after contact has been regained after firing.
6. When the JB switch is in the OWN SHIP position, the only thing plotted on the screen is own ship's course and speed.
7. Standby.
8. Electrically.
9. By a spot of light which flashes on the screen every time a ping goes out.

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CHAPTER 12

MAINTENANCE

1. The Bureau of Ships instruction book for the equipment is the most important source of maintenance information.
2. POMSEE stands for Performance, Operational, and Maintenance Standards for Electronic Equipment.
3. The interval should be 1.25 seconds between transmissions on the 1000-yard scale.
4. The three positions of the pulse length switch are short, medium, and long.
5. Only one class of material.
6. The parts should be lubricated annually and quarterly.
7. Beam patterns are taken to determine that equipment is operating properly.
8. Once a week a cleaning program should be performed.
9. The basic guide for destruction of classified matter is *U. S. Navy Security Manual for Classified Matter.*
10. When reporting electronic failures, the circumstances existing when failure occurs under actual operating conditions must be verified and reported accurately.
11. Information concerning maintenance of Electronic Equipment History Cards is contained in chapter 67 of *BuShips Manual.*

CHAPTER 13

COMMUNICATIONS

1. Sonar Set AN/UQC–1 provides CW voice communication up to about 12,000 yards.
2. The four main components of the AN/UQC–1 are the sonar set control (operator's position), receiver-transmitter, power supply, and transducer.
3. Don't operate the sonar set on CW TRANSMIT for more than 30 minutes at a time because there is a tendency for the transducer to overheat.
4. A dit is one-third the length of a dah.
5. An overscore above a prosign means that the prosign is sent as one character—that is, without the normal pause between letters.

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6. The prosign $\overline{BT}$ separates the text of a sonar message from call and ending.
7. CW call signs of ships of the United States Navy always begin with N and have four letters.
8. All CW sound messages end with either K, used when a reply is expected, or with $\overline{AR}$, used when no reply is expected or desired.
9. The underwater telephone equivalents of K and $\overline{AR}$ are, respectively, OVER and OUT.
10. A sender can cancel an underwater telephone message he is transmitting by the proword DISREGARD THIS TRANSMISSION.
11. Never try to count the dits and dahs of Morse code because when the code speed picks up you will not be able to count fast enough.

CHAPTER 14

HARBOR DEFENSE

1. He is responsible to the local defense force commander.
2. It is the center of the entire harbor defense system.
3. (a) Magnetic loops; (b) cable-connected hydrophones; (c) radio sonobuoys; (d) heralds.
4. The net line divides the protected anchorage from the inner defense area.
5. It is known as the harbor entrance patrol line.
6. The harbor defense commander controls the harbor entrance, inner harbor, and the inshore patrols.
7. The three types of defensive minefields are interception, exclusion, and antisubmarine trap.
8. The surface surveillance elements are radar, searchlight batteries, and visual lookout stations.
9. The two types of plots are the situation plot and the antisubmarine (A/S) plot.
10. The status board gives a record of the over-all harbor defense situation.
11. The officer in charge of underwater detection is the underwater detection officer (UDO). His assistant is the leading Sonarman.

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CHAPTER 15

MAGNETIC LOOPS

1. Another term for magnetic flux is magnetic lines of force.
2. The cutting of flux lines is measured by the fluxmeter.
3. The recorded indication of a ship's loop crossing is called the signature.
4. The movement of the pen, as compared with the movement of the galvanometer coil, is greatly magnified.
5. The shunt switch is a shorting switch that prevents induced voltages in the loop from entering the fluxmeter when the latter equipment is not in operation.
6. The multiplier setting governs the amount of loop voltage which is allowed to enter the fluxmeter.

CHAPTER 16

HYDROPHONES AND HERALDS

1. A period of 3 to 4 seconds has been found to be the best for hydrophone listening.
2. Rough weather increases the underwater noise level of a harbor.
3. The acoustic mirror deflects outgoing sonar pulses from the herald transducer and directs incoming echoes toward the transducer.
4. The water station unit is that part of the herald which is planted on the harbor bottom. Among other things, it contains the transducer and the acoustic mirror.
5. Four pairs of hydrophones.
6. The Mk 6 Mod 0 acoustic system is planted ahead of the acoustic mines.
7. The attenuators control the audio portion of the circuits.
8. Three: raised, normal, and depressed.
9. It gives a permanent signature of a vessel passing the hydrophones at a given time.
10. Its purpose is detection of small sneak craft.
11. It provides ranges from 0 to 600 yards.
12. Bearing markers are controlled by training the handwheel on the console.

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CHAPTER 17

SONOBUOY

1. The artificial ground plane supplies a sheet of good conductivity.
2. The moored sonobuoy will transmit for distances of 10 miles or more.
3. Moored sonobuoys transmit on frequencies between 70 and 90 megacycles.
4. The three safety features included in the battery raft are: Gas-tight housing, breather valve, and vacuum fuses.
5. When a vacuum-type fuse blows, it will not ignite accumulated gases.
6. The pitch of target sounds is compared at two or more stations.
7. The latest type sonobuoy receiver may be tuned automatically or by pushbutton.

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APPENDIX II

QUALIFICATIONS FOR ADVANCEMENT IN RATING

SONARMEN (SO)

Rating Code No. 0400

General Service Rating

Scope

Sonarmen operate (manipulate and interpret data derived from) sonar equipment and underwater fire control equipment for solution of practical problems of antisubmarine and submarine warfare, and perform operational and preventive maintenance on sonar equipment. When assigned to harbor defense, sonarmen operate and perform operational and preventive maintenance or sonic, electronic, and magnetic harbor defense underwater detection equipment.

Emergency Service Ratings

SONARMEN G (Sonarmen), Rating Code No. 0401..... **SOG**
Operate (manipulate and interpret data derived from) sonar equipment and underwater fire control equipment for solution of practical problems of antisubmarine and submarine warfare; perform operational and preventive maintenance on sonar equipment.

SONARMEN H (Harbor Defensemen), Rating Code No. 0402.... **SOH**
Operate (manipulate and interpret data derived from) and perform operational and preventive maintenance on sonic, electronic, and magnetic harbor defense underwater detection equipment.

Navy Enlisted Classification Codes

For specific Navy enlisted classification codes included within this rating, see Manual of Navy Enlisted Classifications, NavPers 15105 (Revised), codes SO-0400 to SO-0499.

NOTE.—The auditory requirements for sonarmen are set forth in current Bureau of Naval Personnel Instructions, Series 1414.

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
100 PRACTICAL FACTORS			
101 OPERATIONAL			
1. Start, stop, operate, tune, and calibrate (limited to operational controls) sonar detection equipment to which assigned, following operational procedures during search, contact, attack, lost contact, and reattack. Investigate search arcs, conduct listening sweeps, and use relative bearing search procedures	3	3	----
2. Start, stop, operate, and calibrate (limited to operational controls) range recorders on own ship or harbor defense station. Use emergency recorder procedures. Compute effective range. Conduct range accuracy test of recorders. Zeroize and make adjustments on the various scales. Use operating controls on recorders in dark or low visibility	3	3	3
3. Operate attack plotter as an aid to maintaining or regaining contact, and in the determination of search arcs, ta get aspect, and target movement. Adjust and use operating controls on attack plotter in dark or low visibility	3	3	----
4. Plot on scope of attack plotter and interpret scope picture to assist in tracking, classifying, and destroying target	3	3	----
5. Start, stop, operate, and calibrate (limited to operational controls) equipment at underwater fire control stations to which assigned	3	3	----
6. Stream and retrieve bathythermograph, including insertion and removal of slide. Prepare, read, interpret, record information (B/T log sheets), file, and ship B/T slides	3	3	3
7. Stream, operate, and recover submarine weapon countermeasures equipment	3	3	----
8. Operate sonar equipment under varying acoustical conditions, including periods during which countermeasures are being employed by own ship or force	3	3	3
9. Recognize and counter submarine evasive devices (decoys and/or jammers), using scanning, depth, and searchlight sonars	3	3	3
10. Start, stop, operate, tune, and calibrate (limited to operational controls) harbor defense underwater detection equipment to which assigned such as			

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
101 OPERATIONAL—Continued			
magnetic indicator loop fluxmeter recorder, sonobuoy radio receivers, hydrophone (acoustic systems) sound receivers, and herald equipment, following operational procedures during search, contact, attack, lost contact, and reattack	3	----	3
11. Interpret recorder traces to determine such information as range, range rate, classification of echoes, target aspect, and weapons' launching time	3	3	3
12. Interpret doppler to identify or determine submarine echo, target movement, target aspect, and submarine evasive devices	3	3	3
13. Identify sonic indications such as screw noise, shaft squeaks, shaft resonance, and propulsion noises caused by surface and subsurface ships and distinguish such indications from natural disturbances caused by marine life	3	3	3
14. Identify, if assigned to harbor defense, magnetic indications (signature) caused by surface and subsurface vessels such as surface ships, submarines, and sneak craft	3	----	3
15. Prepare and interpret sonar—B/T standard and expanded—messages	3	3	3
16. Send and receive international Morse code (plain language) at rate of 8 words a minute (w. p. m.) on standard sonar equipment. Prepare international Morse code messages including call signs, prosigns, and operating signals for transmission by sonar	3	3	3
17. Furnish each station of the following sonar organizations with sonar reports—using S/P and/or R/T procedure, standard phraseology, and proper sequence—for conducting A/S operations:			
a. Shipboard sonar attack organization including bridge, sonar control, UB plot, CIC, and weapons' station personnel	3	3	----
b. Harbor defense organization including harbor defense command center, underwater detection, harbor entrance control post, net gate, and surface detection	----	----	3
c. Ship to ship (surface and subsurface)	3	3	----
18. Demonstrate and observe safety precautions in operation of sonar equipment	3	3	3

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
101 OPERATIONAL—Continued			
19. Operate attack plotter as an attack directing device and fire control instrument—for D/C and/or ATW—to determine information such as attack course, range, mount train and/or tilt, and weapons' launching time	2	2	----
20. Take beam patterns, background noise level measurements, and perform range and bearing accuracy test	2	1	1
21. Start, stop, operate, and calibrate equipment at all underwater fire control stations on own ship	1	1	----
22. Act as conning officer during single and coordinated ship A/S attack	C	C	----
102 MAINTENANCE AND/OR REPAIR			
1. Demonstrate and observe while servicing equipment, safety precautions such as tagging switches, removing fuses, grounding test equipment, and using shorting bar and rubber mats	3	3	3
2. Demonstrate under simulated conditions the rescue of a person in contact with an energized electrical circuit, resuscitation of a person unconscious from electrical shock, and treatment for electrical and acid burns	3	3	3
3. Manipulate operating controls; perform operational tests and make operator's adjustments; read and interpret dials, meter indications, and cathode ray tube presentations on equipment to which assigned	3	3	3
4. Locate and identify by reference to technical maintenance publications, block diagrams and installations blueprints, components, assemblies, subassemblies, and primary and casualty power circuits of sonar equipment	3	3	3
5. Read schematic and wiring diagrams, sonar technical maintenance publications, and installation blueprints; identify and interpret electrical, electronic, and mechanical symbols shown in schematic and wiring diagrams, sonar technical maintenance publications, and installation blueprints	3	3	3
6. Identify electrical characteristics of circuit components such as electron tubes, capacitors, resistors, and internal connections employed in electronic			

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
102 MAINTENANCE AND/OR REPAIR—Continued			
circuits by RETMA color coding and other circuit marking systems	3	3	3
7. Identify by marking systems, interconnecting cables used in sonar equipment	3	2	2
8. Select, use, and maintain hand tools and small portable power tools provided for maintenance and repair of sonar equipment	3	3	3
9. Inspect, clean, and lubricate sonar equipment in accordance with technical maintenance publications	3	3	3
10. Make electrical connections and splices including soldered joints	3	3	3
11. Operate the following test equipment:			
a. Nonelectronic volt-ohm-ammeter	3	3	3
b. Tube tester	3	3	3
c. Megohmmeter (electronic and nonelectronic)	3	3	3
d. Wheatstone bridge	3	3	3
12. Operate the following test equipment:			
a. Oscilloscope	2	2	2
b. Electronic volt-ohm-ammeter	2	2	2
c. Capacitance-inductance-resistance bridge	2	2	2
d. Signal generator (RF, AF, and video)	2	2	2
e. Range mark generator	2	2	2
f. Wattmeter	2	2	2
g. Sonar portable testing equipment (OCP, OAX, BQM−1 or equivalent)	2	2	2
13. Test electronic circuits for continuity, short circuits, and grounds; measure electrical quantities such as voltage, current, power, and frequency and compare with established values; use an oscilloscope to view circuit waveforms and compare with established optimum performance waveforms required in sonar equipment	2	2	2
14. Make tests for short circuits, grounds, and continuity of interconnecting cables between components of sonar equipment	2	2	2
15. Perform sensitivity, selectivity, and source level measurements to determine operational performance of sonar equipment	2	2	2
16. Inspect and clean commutators and slip ring assemblies; inspect and replace brushes	2	2	2

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
102 MAINTENANCE AND/OR REPAIR—Continued			
17. Localize equipment casualties to components of a set or system of sonar equipment	2	2	2
18. Test, repair, and/or replace parts such as relays, plugs, lamps, fuses, switches, tubes, jacks, cables, wiring, fixed capacitors, variacs, variable capacitors, transformers, fixed resistors, and potentiometers within a component, assembly, or subassembly	2	2	2
19. Localize equipment casualties to parts or subassemblies of sonar equipment; repair by replacement of subassemblies or parts	1	1	1
20. Perform tests, adjustments, and repairs necessary for proper operation of sonar components, including analysis of casualties in automatic keying devices, transmitters, transducers, receivers, and indicators	1	1	1
21. Perform tests, adjustments, and repairs necessary for proper operation of electromechanical servomechanisms and synchro control circuits including:			
a. Electrical zeroing of synchros	1	1	1
b. Testing servomotors and amplidynes	1	1	1
c. Gain, phase, and balancing adjustments	1	1	1
22. Effect authorized field changes to sonar equipment in accordance with instructions and diagrams	1	1	1
23. Analyze and evaluate electrical and electronic tests; make adjustments, calibrations, and repairs necessary for optimum performance of sonar equipment	C	C	C
24. Test and evaluate for proper and secure installation and optimum performance new or overhauled components, assemblies, or subassemblies of sonar equipment	C	C	C
103 ADMINISTRATIVE AND/OR CLERICAL			
1. Record operational data on recorder traces and operating logs such as Sonar Operator's Log, Bathythermograph Log, and fluxmeter recorder	3	3	3
2. Locate information in operator's manuals and technical and maintenance publications, necessary for operation, maintenance, and repair of sonar equipment; enter corrections to publications when changes occur	3	3	3

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
103 ADMINISTRATIVE AND/OR CLERICAL—Continued			
3. Obtain parts and stock numbers from technical and supply publications and prepare requisitions for tools and replacement parts	3	3	3
4. Take, record, and report inventories of tools and portable test equipment available for maintenance and repair of sonar equipment	3	3	3
5. Record test data and work accomplished in sonar maintenance logs, equipment histories, and checkoff lists	2	2	2
6. Obtain information for and prepare and complete entries in electronic (sonar) equipment failure reports	2	2	2
7. Train, drill, and supervise A/S teams on synthetic training devices and at cruising watch or general quarters stations	1	1	1
8. Administer maintenance and repair (performed by sonar personnel) of sonar equipment	1	1	1
9. Prepare and complete periodic or recurring reports concerning performance and/or maintenance of sonar equipment	1	1	1
10. Prepare job orders and/or work requests	1	1	1
11. Organize, supervise, and train personnel in operation, maintenance, and repair of sonar equipment	C	C	C
12. Evaluate completed electronic (sonar) equipment failure reports, electronic (sonar) equipment histories, operational and maintenance logs, checklists, requisitions for tools and replacement parts, inventories of tools and portable test equipment, job orders, work requests, and periodic or recurring reports concerning performance and/or maintenance of electronic (sonar) equipment	C	C	C
200 EXAMINATION SUBJECTS			
201 OPERATIONAL			
1. Nomenclature and function of listening and echo-ranging sonar detection equipment—searchlight and scanning—and its capabilities	3	3	3
2. Stack operation during search, contact, attack, no echoes, lost contact, and reattack, using cut-on, BDI, and scanning procedures	3	3	----

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
201 OPERATIONAL—Continued			
3. Interpretation of recorder traces to determine such information as range, range rate, classification of echoes, target aspect, and weapons' launching time	3	3	3
4. Use of attack plotter as an aid in maintaining or regaining contact and in determination of search arcs, target aspect, and target movement	3	3	----
5. Operational procedures for and functions of horizontal and slant range recorders	3	3	----
6. Operational procedures for and functions of depth-determining equipment	3	3	----
7. Care and use of bathythermograph. Preparation, reading, interpretation, recording of information (B/T log sheets), filing, and shipping of B/T slides	3	3	3
8. Characteristics and use of submarine-controlled jamming and evasive devices such as stationary false targets, mobile false targets, and noisemakers	3	3	3
9. Operating procedures, including evasive maneuvers and sonar equipment operation, used against submarine-controlled jamming and evasive devices	3	3	3
10. Procedures for streaming, operating, and recovering submarine weapons' countermeasures equipment	3	3	----
11. Nomenclature and functions of magnetic loop detection equipment and sonic (hydrophones, heralds, and moored sonobuoys) detection equipment and their capabilities	3	----	3
12. Magnetic loop method of detecting surface and submersible craft, employing the following operational procedures: Fluxmeter operations, interpretation of signature, voice reports, and logging of pertinent information on recorder chart and station log	3	----	3
13. Characteristics of moored sonobuoys including such information as purpose, frequency range, effective range, and effects of weather, spacing, and battery supply	3	----	3
14. Shipboard A/S search and attack organization including functional relationship of bridge, sonar control, UB plot, CIC, and weapons' station personnel	3	3	----
15. Duties of personnel assigned to sonar control, UB plot, and A/S ordnance stations, such as A/S officer, A/S watch officer, sonar supervisor, sonar search			

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
201 OPERATIONAL—Continued			
operator, firing petty officer, weapons' station personnel, AP, AD, TRR, and depth determining operators	3	3	----
16. Duties of personnel assigned to harbor defense components such as UD watch officer, UD supervisor, plotter, herald operator, acoustic system operator, magnetic loop operator, and talker	----	----	3
17. Listening and echo-ranging methods—searchlight and scanning—of detecting surface and submersible craft	3	3	3
18. Single ship sonar search procedures including standard sonar ranging and listening patterns, investigation of search arcs, and conducting listening sweeps during no echoes, lost contact, and relative bearing search procedures	3	3	----
19. Three elements—description, recognition, and classification—in A/S investigation of a contact; four categories of sonar contacts and determination of sonar contacts employing classification aids and/or practices such as:			
a. Evaluation of echo quality	3	3	3
b. Evaluation of doppler	3	3	3
c. Evaluation of scanning sonarscope	3	3	3
d. Evaluation of range recorder traces	3	3	3
e. Evaluation of wakes	3	3	3
f. Evaluation of hydrophone effects	3	3	3
g. Evaluation of sea condition	3	3	3
h. Determination of contact width and movement	3	3	3
20. Physics of sound including refraction, attenuation, and doppler effect as applied to sonar and harbor defense underwater detection equipment. Variations in physical properties of water and effect of boundaries—surface, thermal, and bottom—on underwater sound. Applications of water phenomena to sonar operations	3	3	3
21. A/S terms and definitions. Concepts of relative motion, true and relative bearings, and their conversion. Determination of target angle, target aspect, doppler, and their relationship in A/S operations	3	3	3
22. Submarine types and their capabilities	3	3	3

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
201 OPERATIONAL—Continued			
23. Communication facilities associated with A/S operations such as sound-powered phones, MC circuits, voice tubes, underwater telephone, automatic remote indicators, and repeaters	3	3	3
24. Standard phraseology (including sound-powered and radio telephone procedures), proper sequence of reports, and information derived, relayed, or received from each station of:			
a. Shipboard sonar attack organization including bridge, sonar control, UB plot, CIC, and weapons' station personnel	3	3	----
b. Harbor defense organization including harbor defense command center, underwater detection, harbor entrance control post, net gate, and surface detection	----	----	3
25. Preparation of international Morse code (plain language) messages including call signs, prosigns, and operating signals for transmission by sonar	3	3	3
26. Safety precautions to be observed in operation of sonar equipment	3	3	3
27. CIC search and attack functions and data application during single ship A/S operations	2	2	----
28. Use of attack plotter as an attack directing device and fire control instrument (for D/C and/or ATW) to determine such information as attack course, range, mount train and/or tilt, and weapons' launching time	2	2	----
29. Preparation and interpretation of sonar (B/T standard and expanded) messages. Application of information furnished by the bathythermograph to A/S operations	2	2	2
30. Effects of sea and weather conditions on A/S operations, causing sonar interference, such as:			
a. Properties of sea water including temperature, salinity, and pressure	2	2	2
b. Wind force and sea state	2	2	2
c. Bottom depth and type	2	2	2
d. Marine life	2	2	2

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
201 OPERATIONAL—Continued			
31. Procedures for taking beam patterns, background noise level measurements, and range and bearing accuracy tests to indicate performance of transducers and equipment	2	1	1
32. Organization of harbor defense underwater detection component and tactical relationship to other components of harbor defense organization	2	----	3
33. Procedures for use of moored sonobuoys, including means of planting, scanning (sonobuoy radio receiver), plotting, and recovery	2	----	2
34. Functions and operations of components of underwater fire control systems such as TRR, AP, DRT, OKA, AD, and associated firing panels	1	1	----
35. Current search doctrines (A/S single and multiship), including standard and special search plans for A/S searches, patrols, and screens; determining keying interval and sonar ranges	1	1	----
36. CIC search and attack functions and data application during single and coordinated ship A/S operations	1	1	----
37. Procedures for conning single and coordinated ship A/S attacks	C	C	----
202 MAINTENANCE AND/OR REPAIR			
1. Effects of electrical shock, method of resuscitation of a person unconscious from electrical shock, and treatment for electrical and acid burns	3	3	3
2. Electrical and electronic safety precautions including those set forth in Chapter 18, U. S. Navy Safety Precautions, OPNAV 34P1, to be observed in servicing sonar equipment	3	3	3
3. Define electrical, magnetic, and electronic terms such as:			
a. Volt	3	3	3
b. Ohm	3	3	3
c. Ampere	3	3	3
d. Watt	3	3	3
e. Volt-ampere	3	3	3
f. Henry	3	3	3
g. Farad	3	3	3
h. Cycle	3	3	3

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
202 MAINTENANCE AND/OR REPAIR—Continued			
i. Ampere-turn	3	3	3
j. Conductors and insulators	3	3	3
k. Field intensity	3	3	3
l. Flux density	3	3	3
m. Permeability	3	3	3
n. Hysteresis and eddy currents	3	3	3
o. Reactance, impedance, capacitance, and inductance	3	3	3
p. Self-inductance and mutual inductance	3	3	3
q. Electromagnetic induction	3	3	3
r. Power factor	3	3	3
s. Frequency	3	3	3
t. Phase	3	3	3
u. RC time	3	3	3
v. Attenuation	3	3	3
w. Amplifier	3	3	3
x. Modulation	3	3	3
y. Decibel	3	3	3
4. System of assigning "AN" letter-number combinations as designation for sonar equipment	3	3	3
5. Types of information shown and meanings of electrical, electronic, and mechanical symbols used in:			
a. Block diagrams	3	3	3
b. Equipment, schematic, and wiring diagrams	3	3	3
c. Sonar technical maintenance publications	3	3	3
d. Installation blueprints	3	3	3
6. RETMA color code and other marking systems used to identify electrical characteristics of circuit components such as electron tubes, electron tube sockets, capacitors, resistors, and internal connections employed in electronic circuits	3	3	3
7. Marking system used with interconnecting cables in sonar equipment	3	3	3
8. Types and purposes of hand tools and small portable power tools provided for maintenance and repair of sonar equipment	3	3	3
9. Lubricants, cleaning materials and solutions used, and safety precautions to be observed in their use in maintenance of sonar equipment	3	3	3

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
202 MAINTENANCE AND/OR REPAIR—Continued			
10. Function of and operating procedures in using the following:			
a. Nonelectronic volt-ohm-ammeter	3	3	3
b. Tube tester	3	3	3
c. Megohmmeter (electronic and nonelectronic)	3	3	3
d. Wheatstone bridge	3	3	3
11. Soldering equipment and methods used in maintenance and repair of electronic equipment	3	3	3
12. Function of and operating procedures in using the following:			
a. Oscilloscope	2	2	2
b. Electronic volt-ohm-ammeter	2	2	2
c. Capacitance-inductance-resistance bridge	2	2	2
d. Signal generator (RF, AF, and video)	2	2	2
e. Range mark generator	2	2	2
f. Wattmeter	2	2	2
g. Sonar portable testing equipment (OCP, OAX, BQM—1, or equivalent)	2	2	2
13. Methods of performing sensitivity, selectivity, and source level measurements to determine operational performance of sonar equipment	2	2	2
14. Methods and equipment used in electrical tests for continuity, grounds, and short circuits	2	2	2
15. Function of elements used in vacuum tubes, cathode ray tubes, and gas tubes	2	2	2
16. Function of parts in electrical and electronic circuits such as resistors, rheostats, potentiometers, solenoids, inductors, capacitors, fuses, switches, reactors, transformers, and relays	2	2	2
17. Methods of obtaining three general types of bias: Fixed, cathode, and gridleak	2	2	2
18. Function and operating principles of components of electronic circuits such as:			
a. Audio amplifiers	2	2	2
b. Video amplifiers	2	2	2
c. RF amplifiers	2	2	2
d. IF amplifiers	2	2	2
e. Oscillators—Hartley crystal-controlled, Colpitts, TPTG, electron-coupled, and basic multivibrator	2	2	2
f. Rectifiers—copper oxide, selenium, crystal, and electron tube	2	2	2

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
202 MAINTENANCE AND/OR REPAIR—Continued			
g. Detectors—diode and crystal	2	2	2
h. Tuned coupling circuits	2	2	2
i. Impedance matching	2	2	2
j. Phase shifters	2	2	2
k. Cathode followers	2	2	2
l. Modulators—grid, screen, and plate	2	2	2
m. Oscillators—blocking and Wein-Bridge	2	2	2
n. Trigger circuits and multivibrators	2	2	2
o. Coincidence circuits	2	2	2
p. Limiters, clippers, and peakers	2	2	2
q. Discriminators	2	2	2
r. AGC and AFC circuits	2	2	2
s. Magnetic amplifiers	2	2	2
19. Meaning of electrical and electronic terms such as: Gain, feedback, bias, cutoff, and grid current; electron tube constants, nonlinear, frequency, and phase distortion; amplitude, frequency, phase, and pulse modulation	2	2	2
20. Function and operating principles of gas-filled tubes and cathode ray tubes	2	2	2
21. Relationship of current, voltage, and impedance in a. c. circuits	2	2	2
22. Relationship of resistance, inductance, and capacitance in a. c. circuits	2	2	2
23. Calculate current, voltage, and resistance in d. c. series and parallel circuits containing not more than four elements	2	2	2
24. Relationship of current, voltage, and impedance in series and parallel resonant circuits at, above, and below resonance	2	2	2
25. Application of low-pass, band-pass, and high-pass filters	2	2	2
26. Methods of coupling: Transformer, impedance, capacitive, resistive, and direct	2	2	2
27. Application and operating principles of wire and coaxial transmission lines	2	2	2
28. Construction of motors, generators, and alternators; application of laws of magnetism to electrical rotating machinery	2	2	2
29. Methods of cleaning commutators and slipring assemblies and precautions to be observed	2	2	2

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Qualifications for Advancement in Rating	Applicable Rates		
	SO	SOG	SOH
202 MAINTENANCE AND/OR REPAIR—Continued			
30. Characteristics and use of synchros and servomotors; methods of setting to electrical zero; purpose of gain, phase, and balance adjustments	1	1	1
203 ADMINISTRATIVE AND/OR CLERICAL			
1. Use of and procedures for recording operational data on recorder traces and in operating logs such as Sonar Operator's Log, Bathythermograph Log, and fluxmeter recorder	3	3	3
2. Types of information contained in sonar operator's manuals, and technical and maintenance publications	3	3	3
3. Procedures for taking, recording, and reporting inventories of tools and portable test equipment used in maintenance and repair of electronic (sonar) equipment	3	3	3
4. Procedures for obtaining replacement parts and supplies	3	3	3
5. Types of entries and information recorded in electronic (sonar) equipment failure reports, maintenance logs, equipment histories, and checkoff lists	2	2	2
6. Types of information included in job orders and work requests	2	2	2
7. Types of information in periodic or recurring reports, concerning performance and maintenance of sonar equipment	1	1	1
8. Planning, organizing, and scheduling training programs in operation, maintenance, and repair of sonar equipment	C	C	C
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